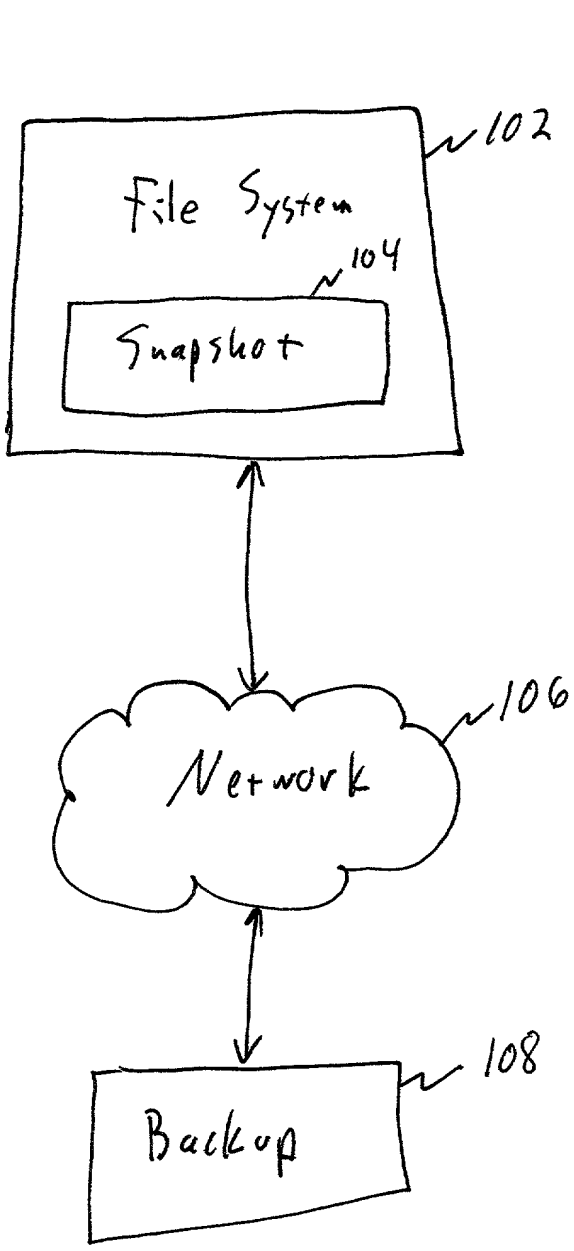

FIG. 1

APPL-P3574.002US1

200

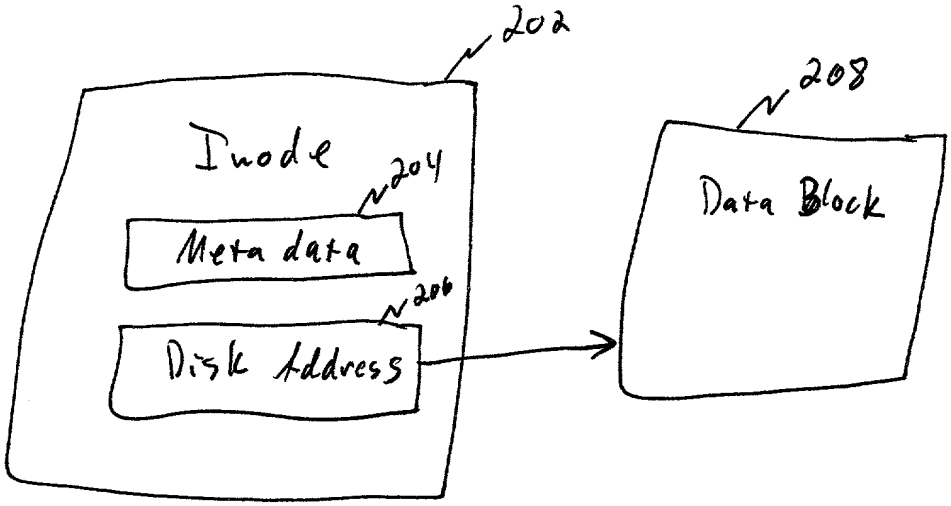

FIG. 2A

2054-2-0-4/5/2004

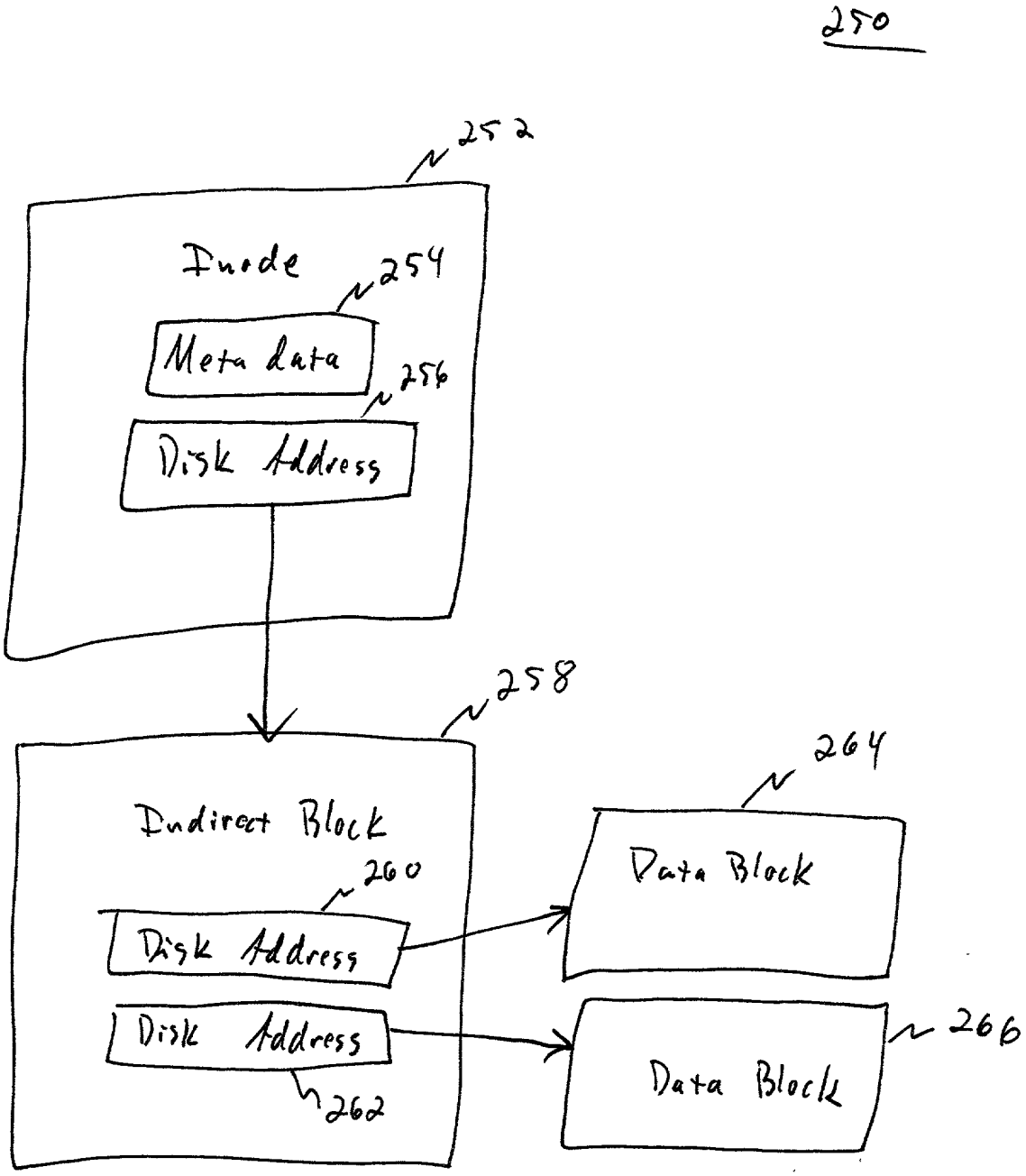

FIG. 2B

10/976,928 - 05/15/08

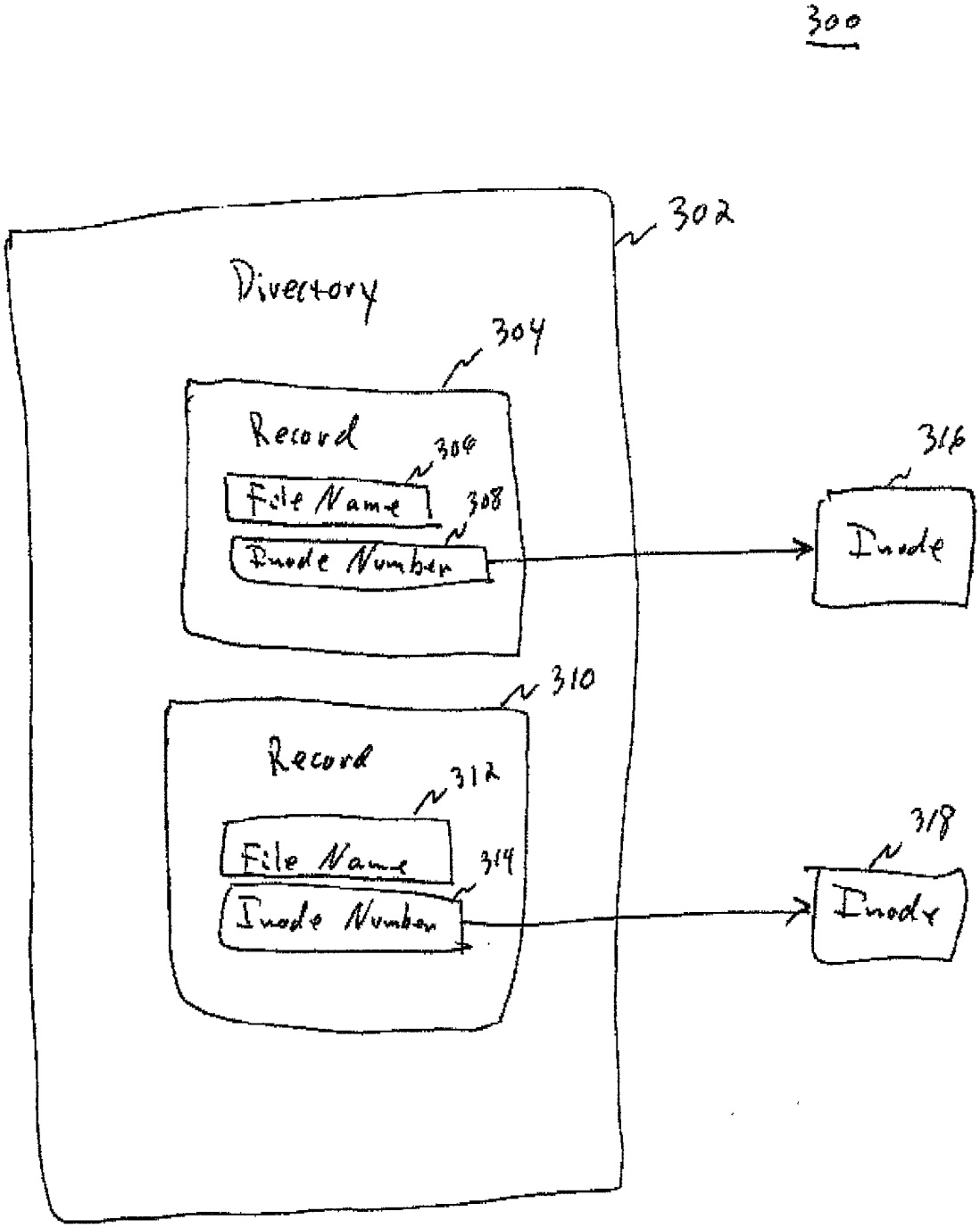

FIG. 3

SOUTHERN OREGON

400

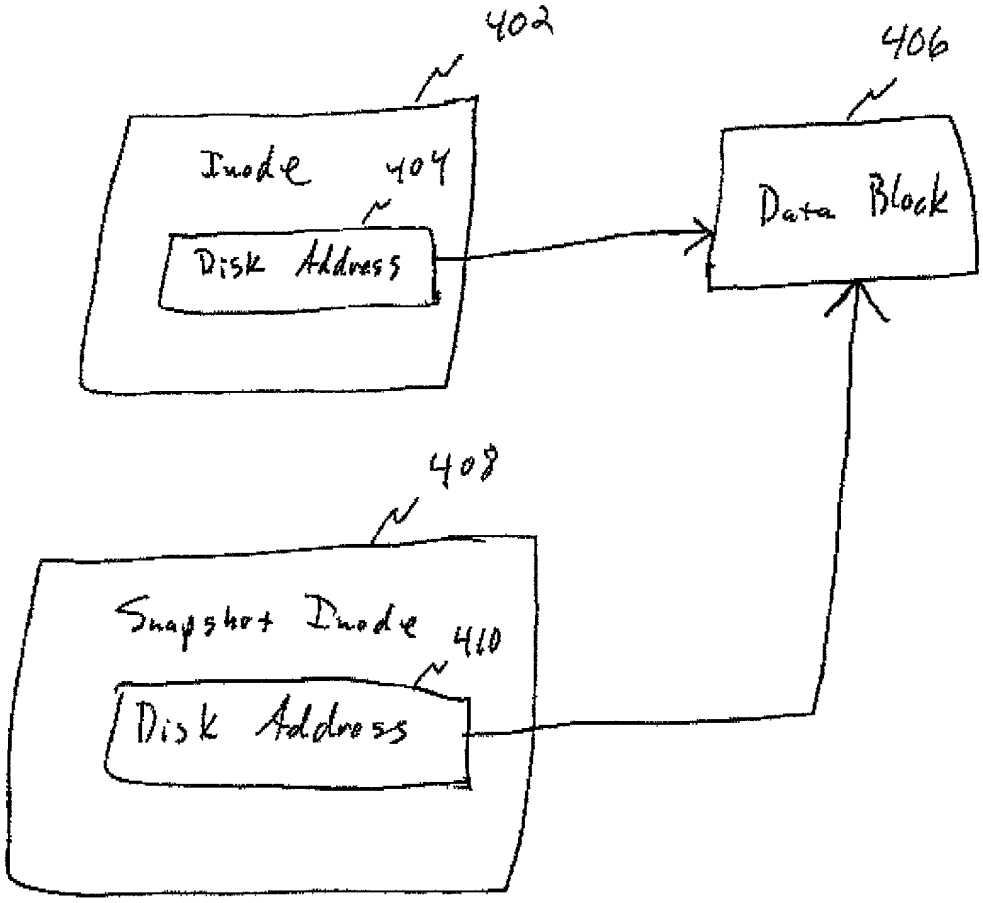

FIG. 4

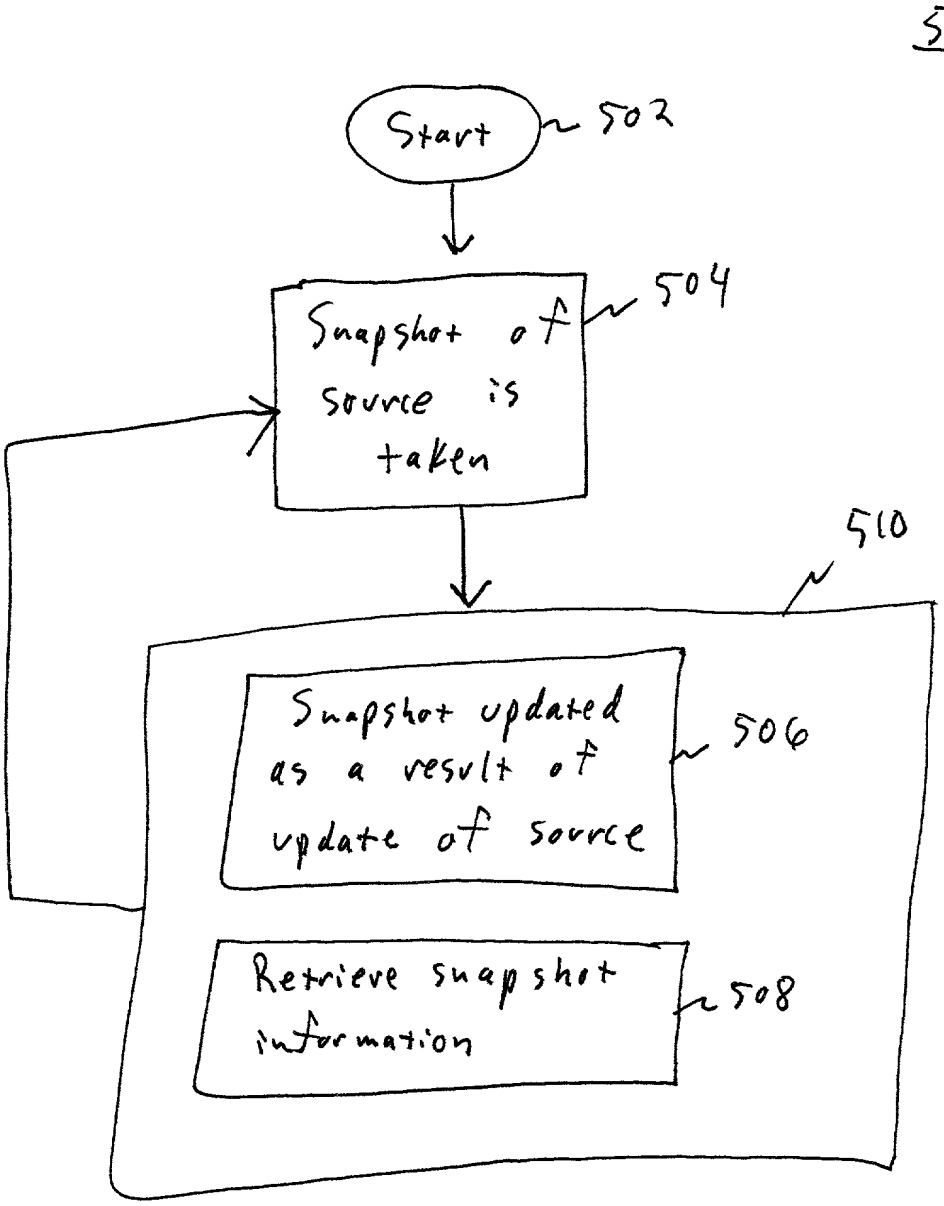
500
Start
502
Snapshot of source is taken
504
510
Snapshot updated as a result of update of source
506
Retrieve snapshot information
508

FIG. 5

Express Mail Label No. EV 045 205 254 US

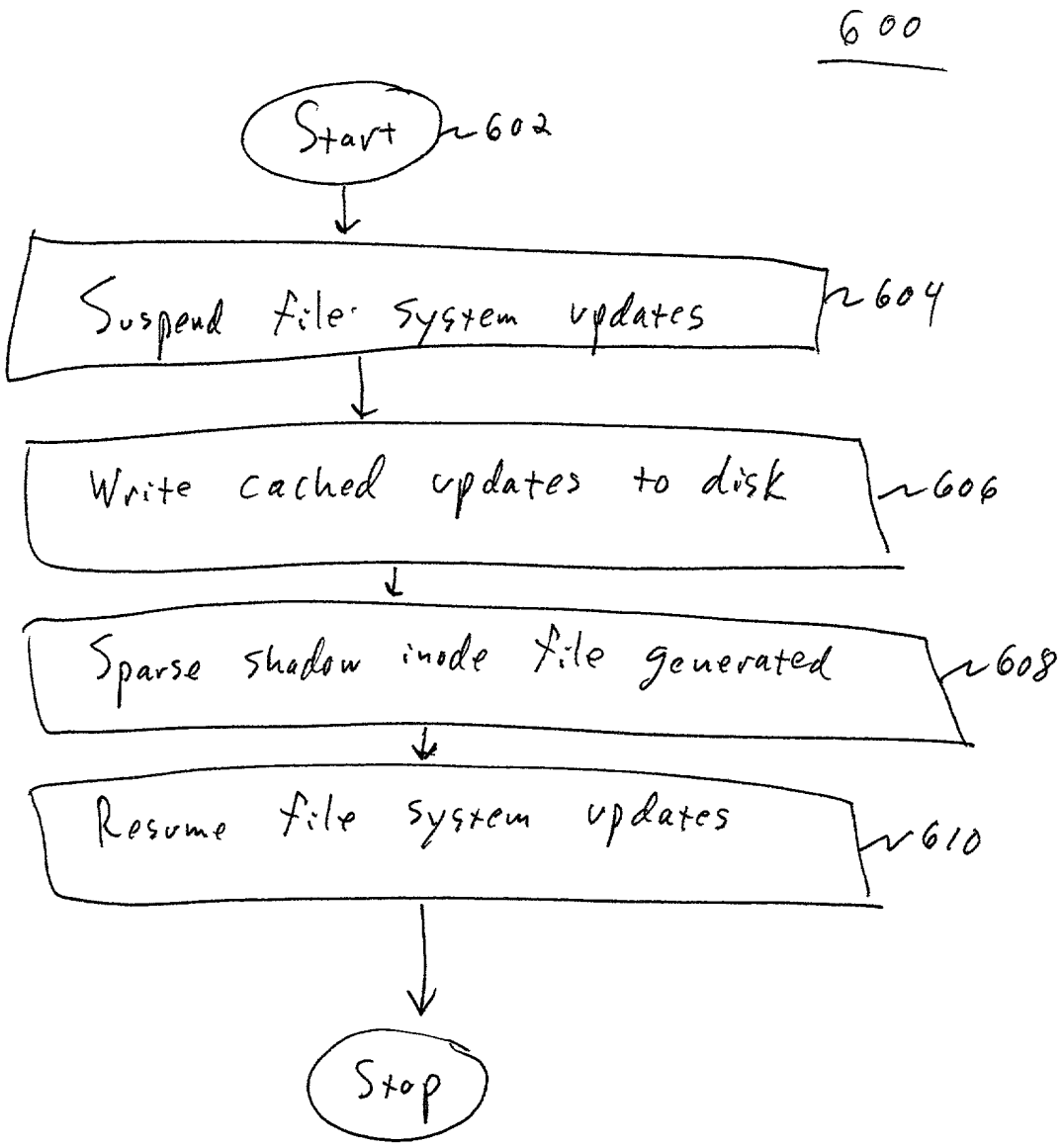

FIG. 6A

620

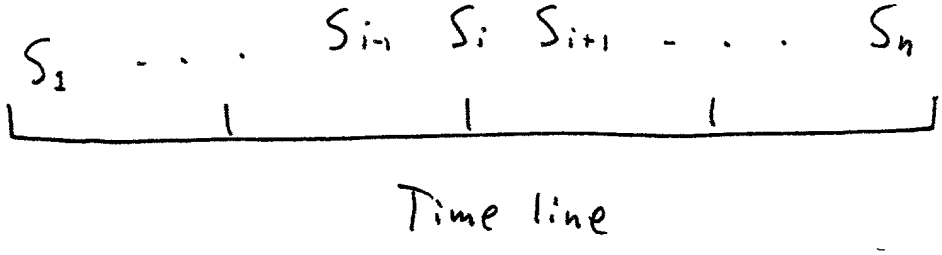

FIG. 6B

US 7,454,592 B1

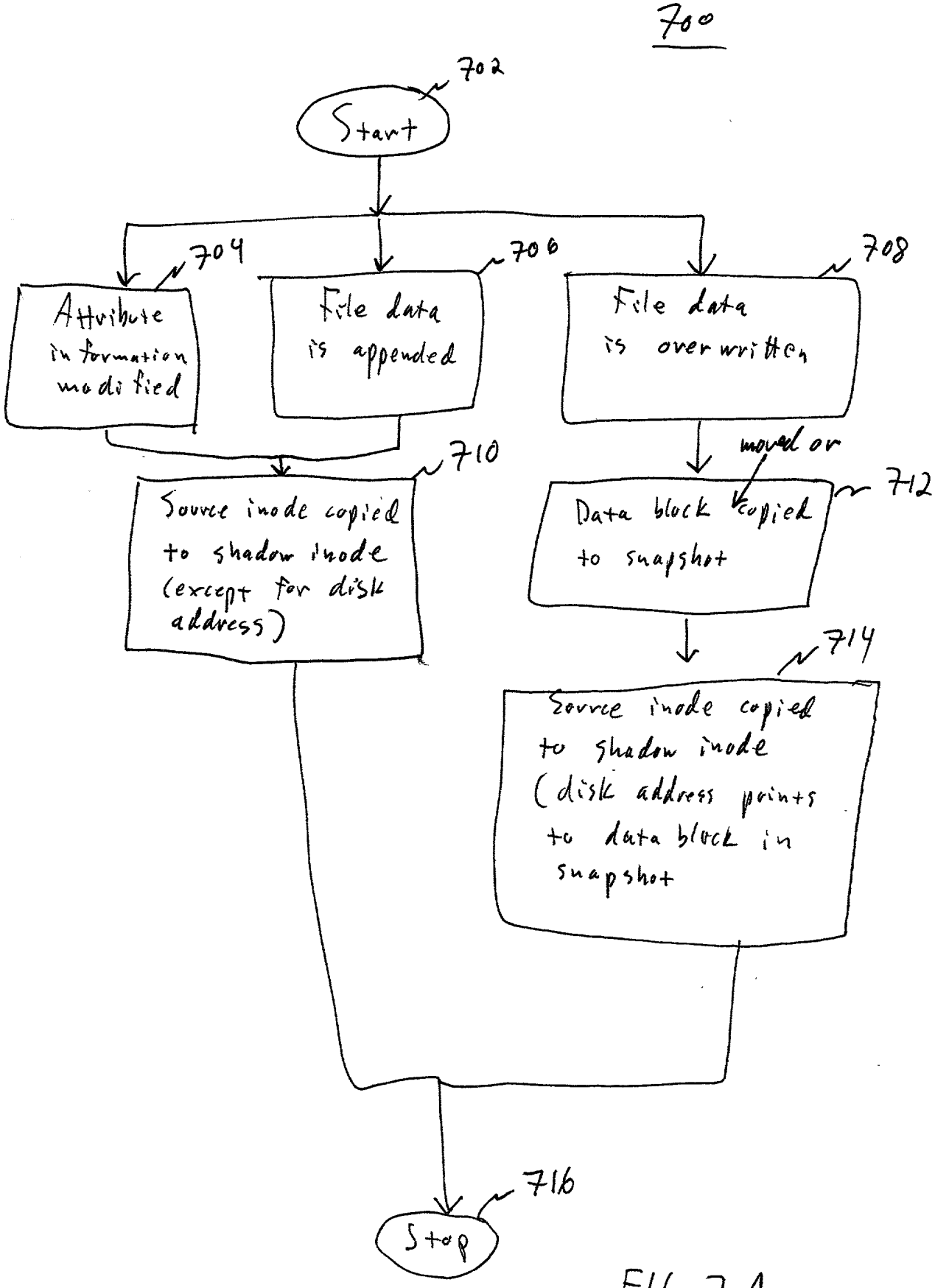

FIG. 7A

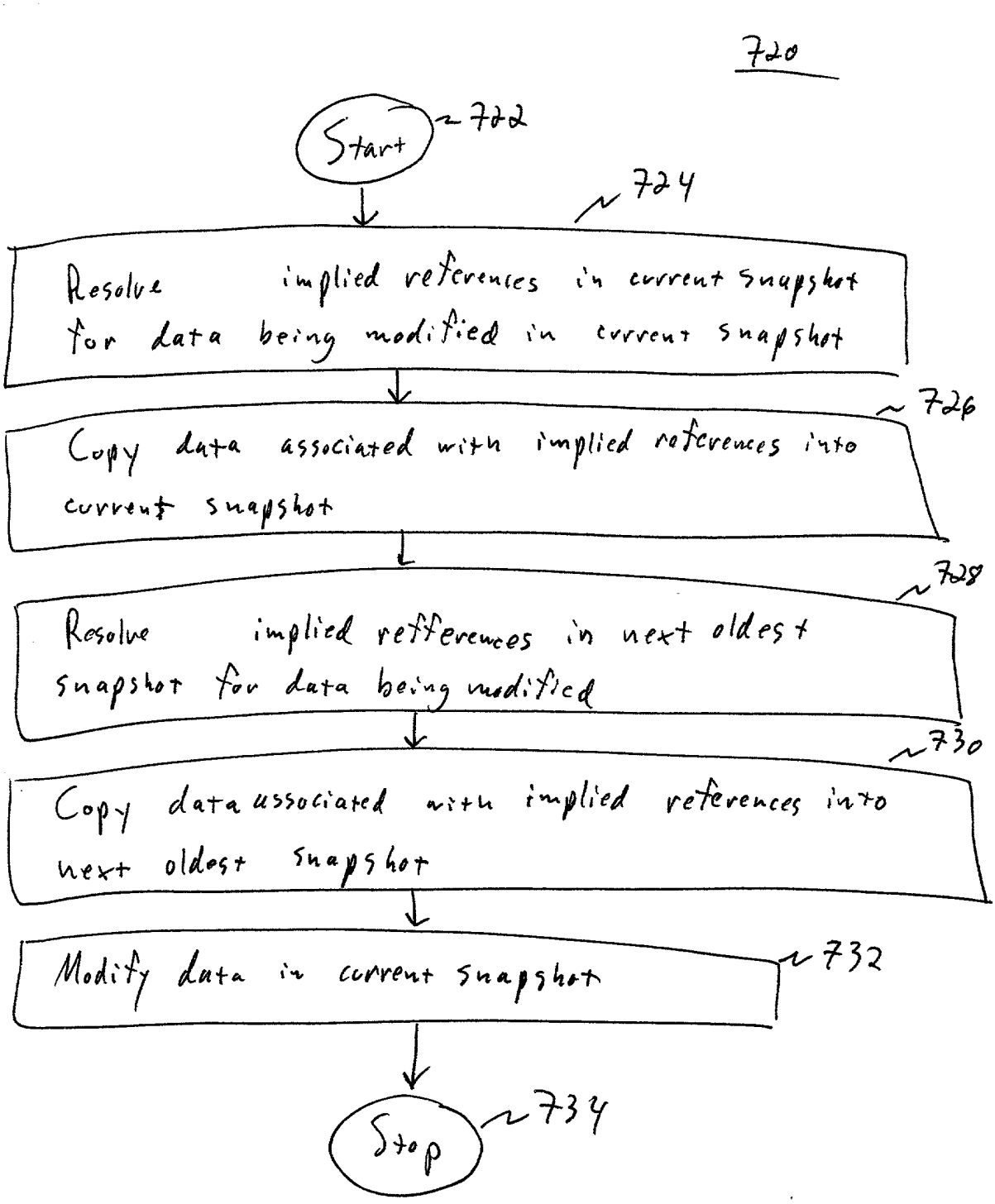
720
Start
722
724
Resolve implied references in current snapshot for data being modified in current snapshot
726
Copy data associated with implied references into current snapshot
728
Resolve implied refferences in next oldest snapshot for data being modified
730
Copy data associated with implied references into next oldest snapshot
Modify data in current snapshot
732
Stop
734

FIG. 7B

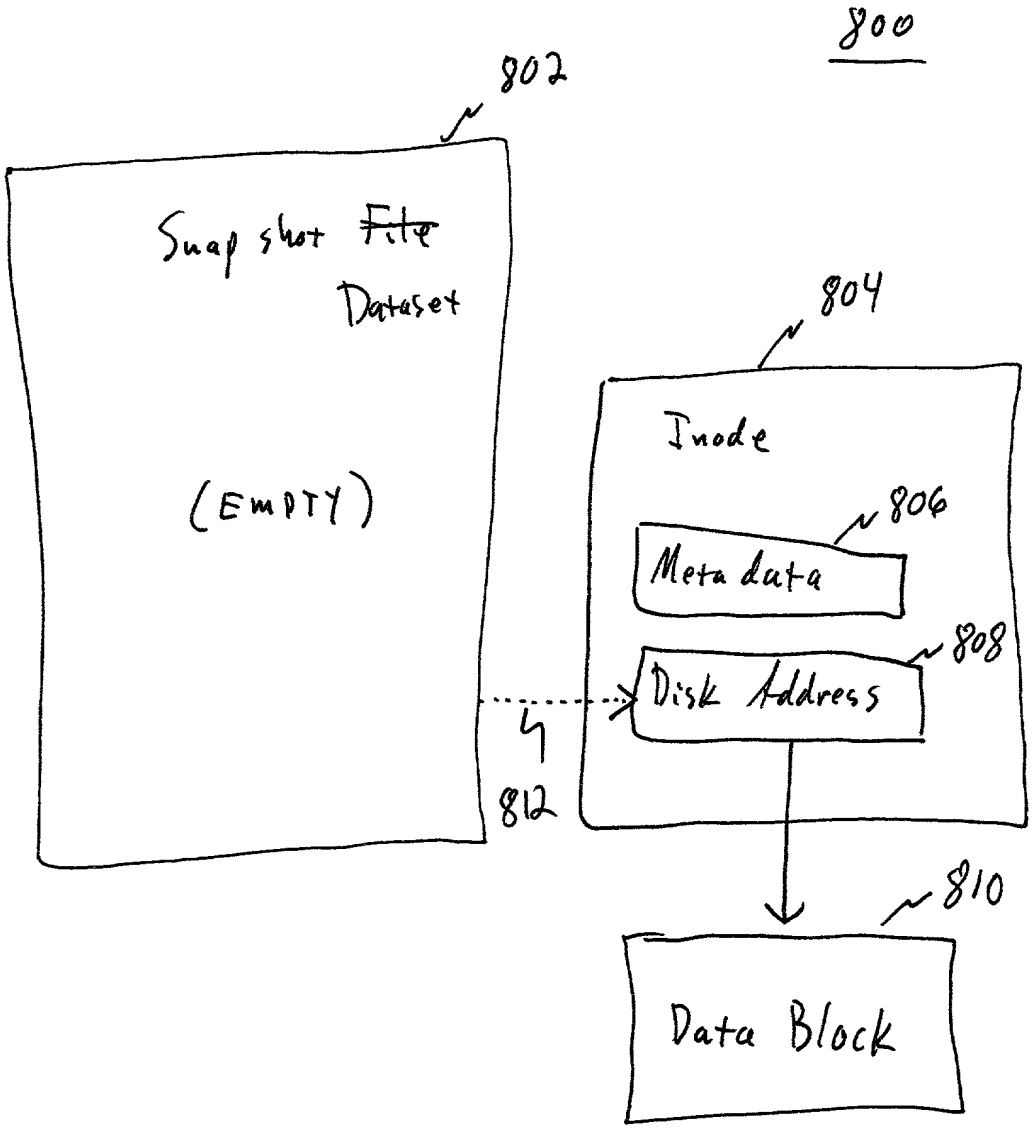
800
802
Snap shot ~~File~~
Dataset
(EMPTY)
804
Inode
806
Meta data
808
Disk Address
812
810
Data Block

FIG. 8A

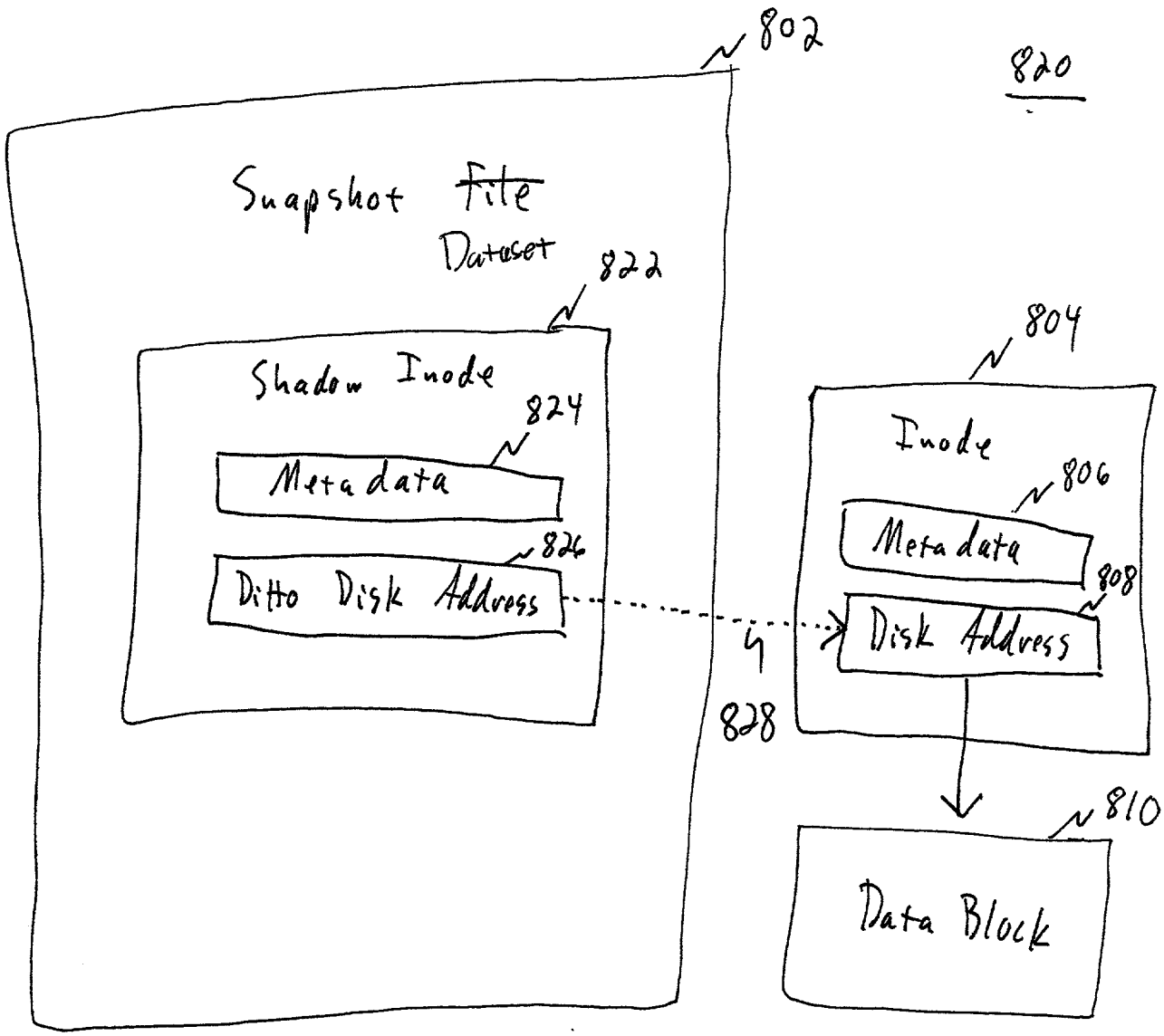
802
820
Snapshot ~~File~~
Dataset
822
Shadow Inode
824
Metadata
826
Ditto Disk Address
804
Inode
806
Metadata
808
Disk Address
828
810
Data Block

FIG. 8B

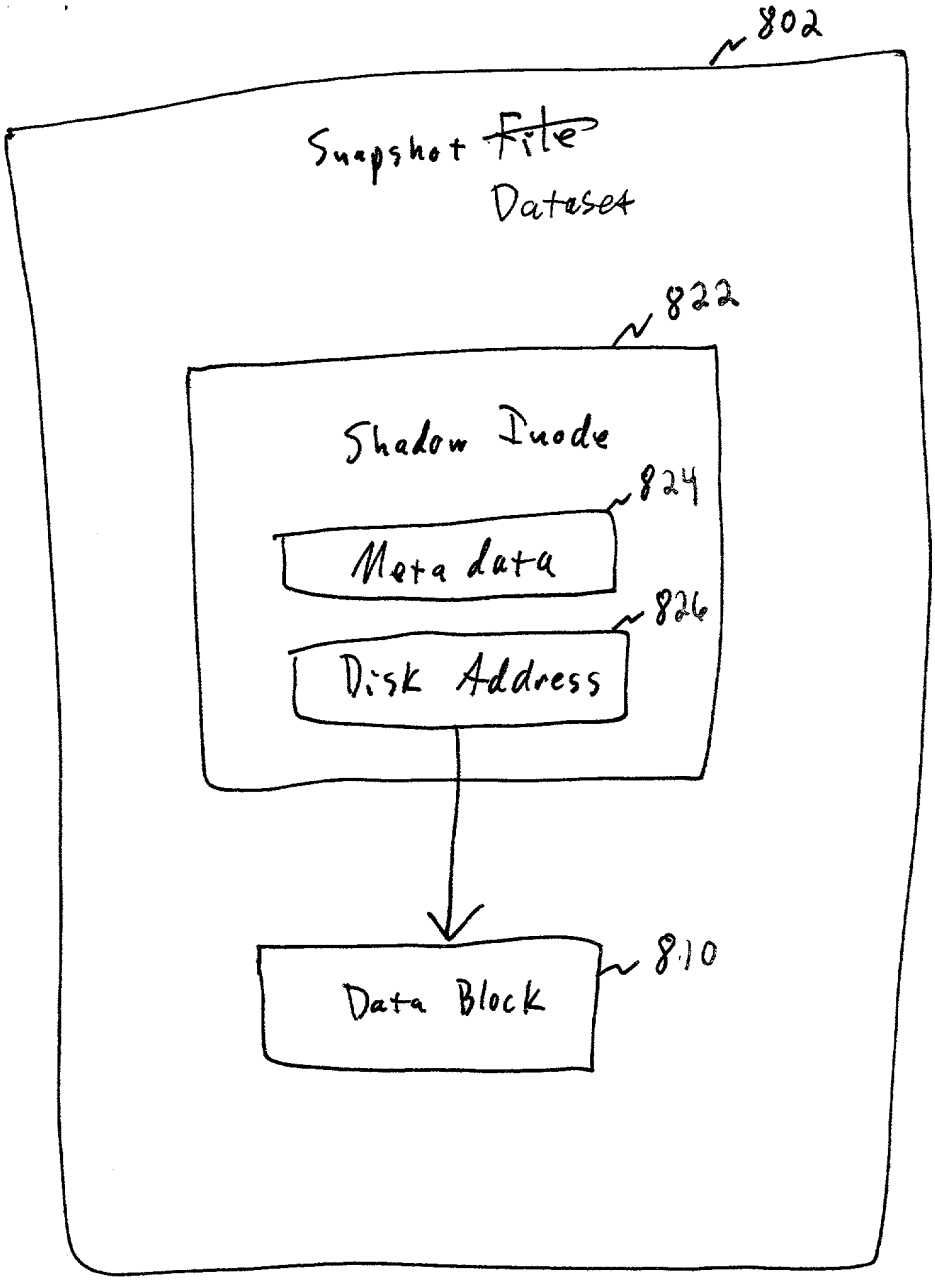
802
830
Snapshot ~~File~~
Dataset
822
Shadow Inode
824
Meta data
826
Disk Address
810
Data Block

FIG. 8C

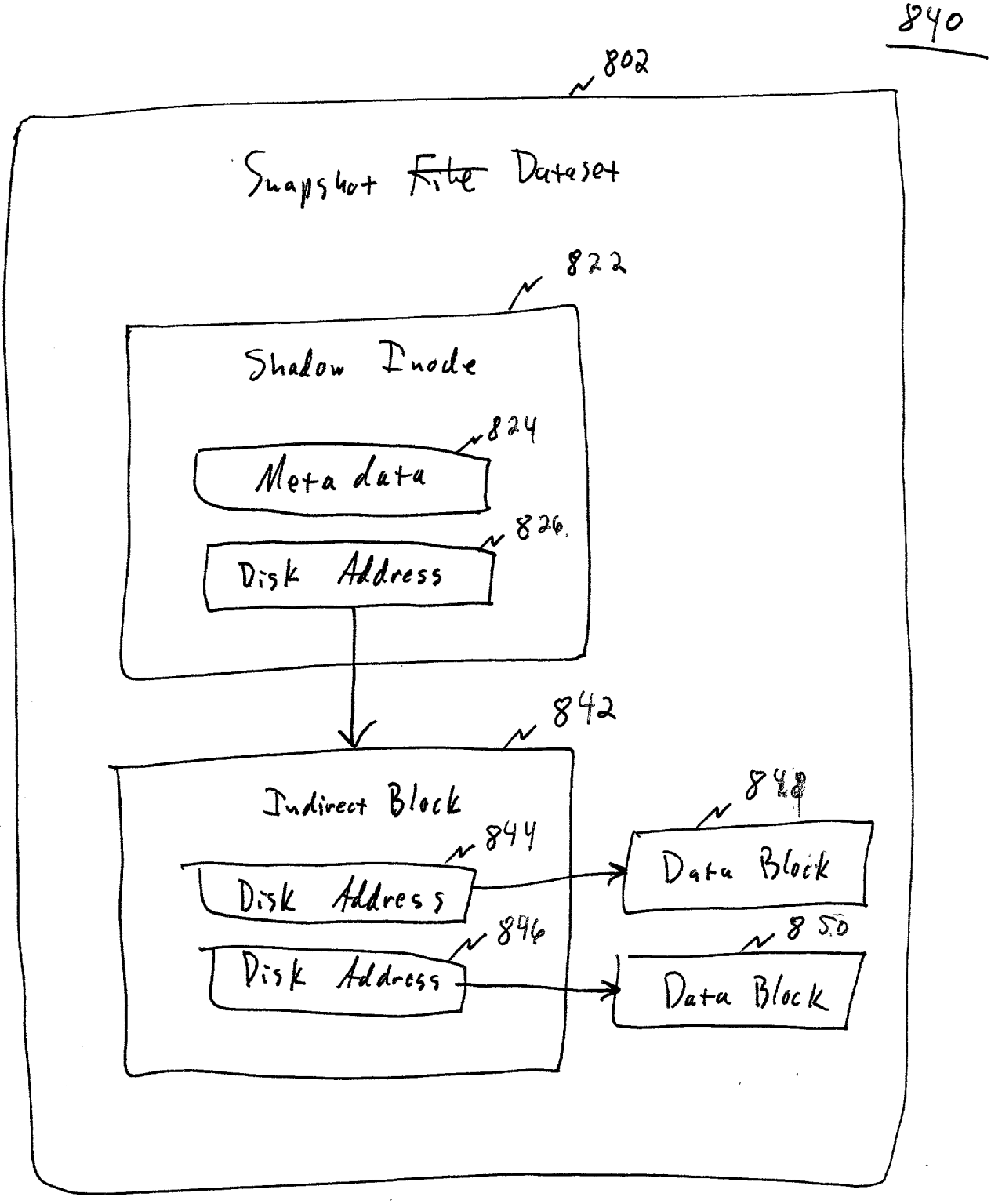
840
802
Snapshot ~~File~~ Dataset
822
Shadow Inode
824
Meta data
826
Disk Address
842
Indirect Block
844
Disk Address
846
Disk Address
848
Data Block
850
Data Block

FIG. 8D

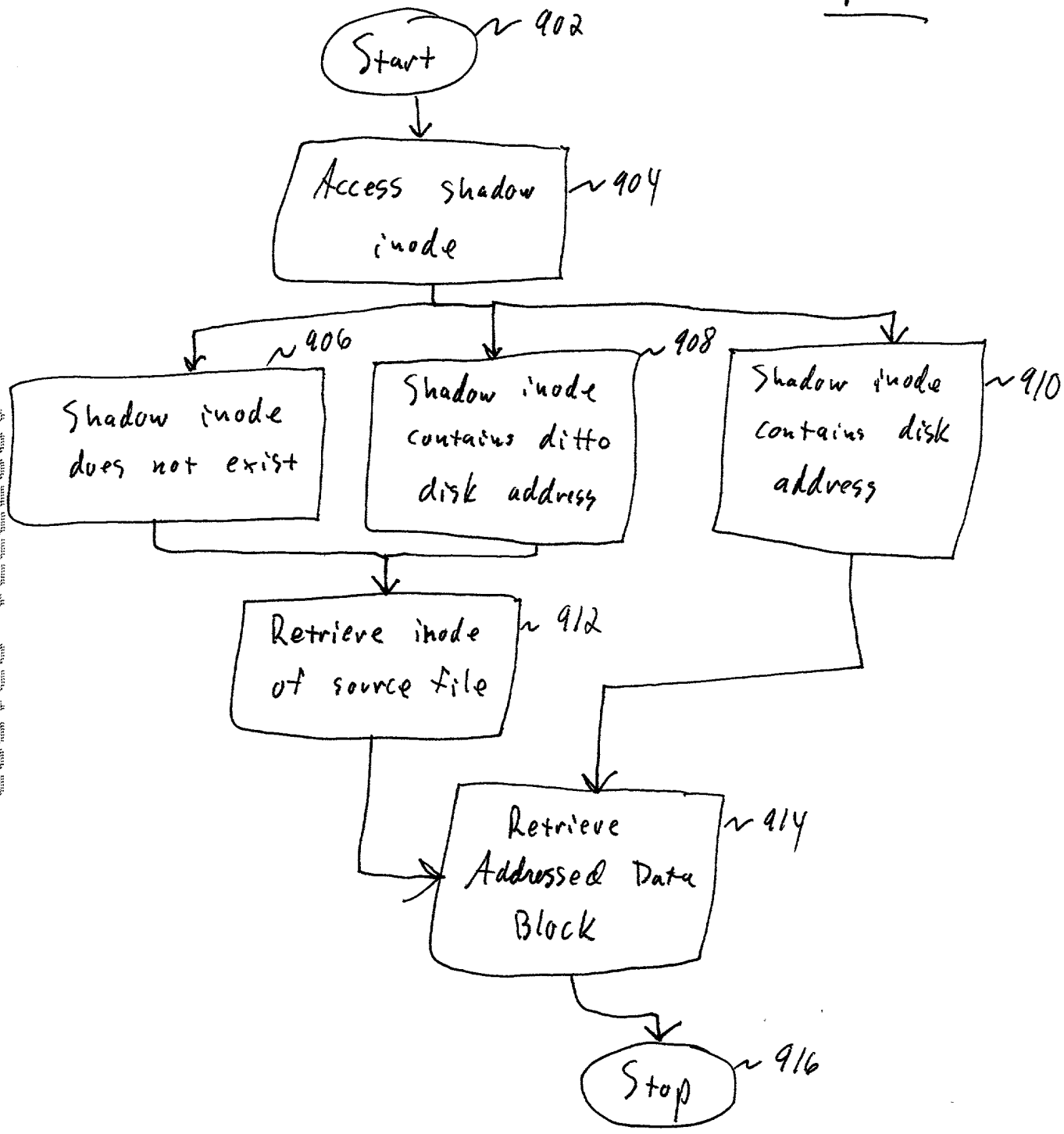
900
Start
902
Access shadow inode
904
Shadow inode does not exist
906
Shadow inode contains ditto disk address
908
Shadow inode contains disk address
910
Retrieve inode of source file
912
Retrieve Addressed Data Block
914
Stop
916

FIG. 9

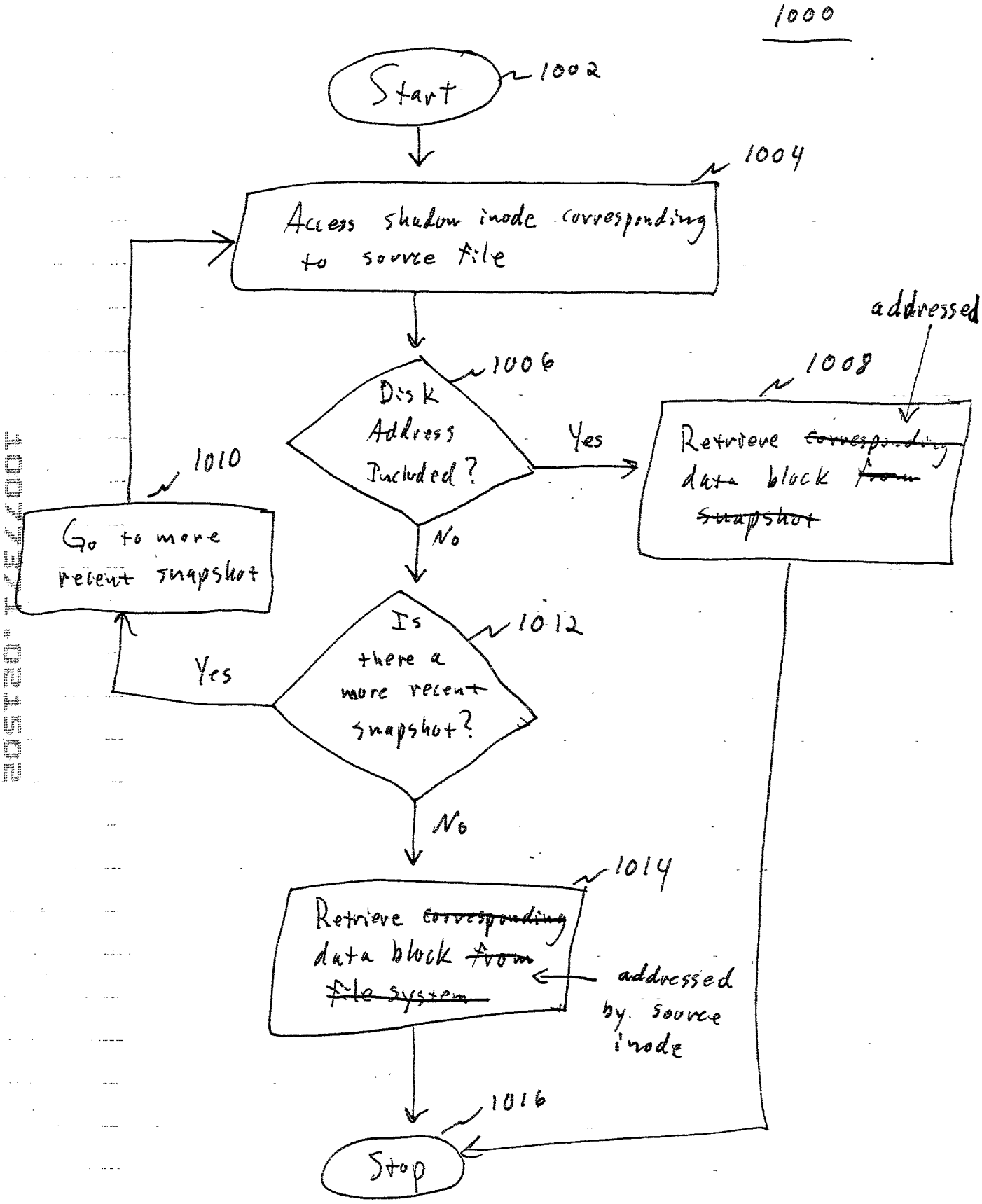
1000
Start
1002
1004
Access shadow inode corresponding to source file
1006
Disk Address Included?
Yes
1008
addressed
Retrieve ~~corresponding~~ data block ~~from~~ ~~snapshot~~
No
1010
Go to more recent snapshot
Yes
1012
Is there a more recent snapshot?
No
1014
Retrieve ~~corresponding~~ data block ~~from~~ ~~file system~~
addressed by source inode
1016
Stop

FIG. 10

4005/5574.005502

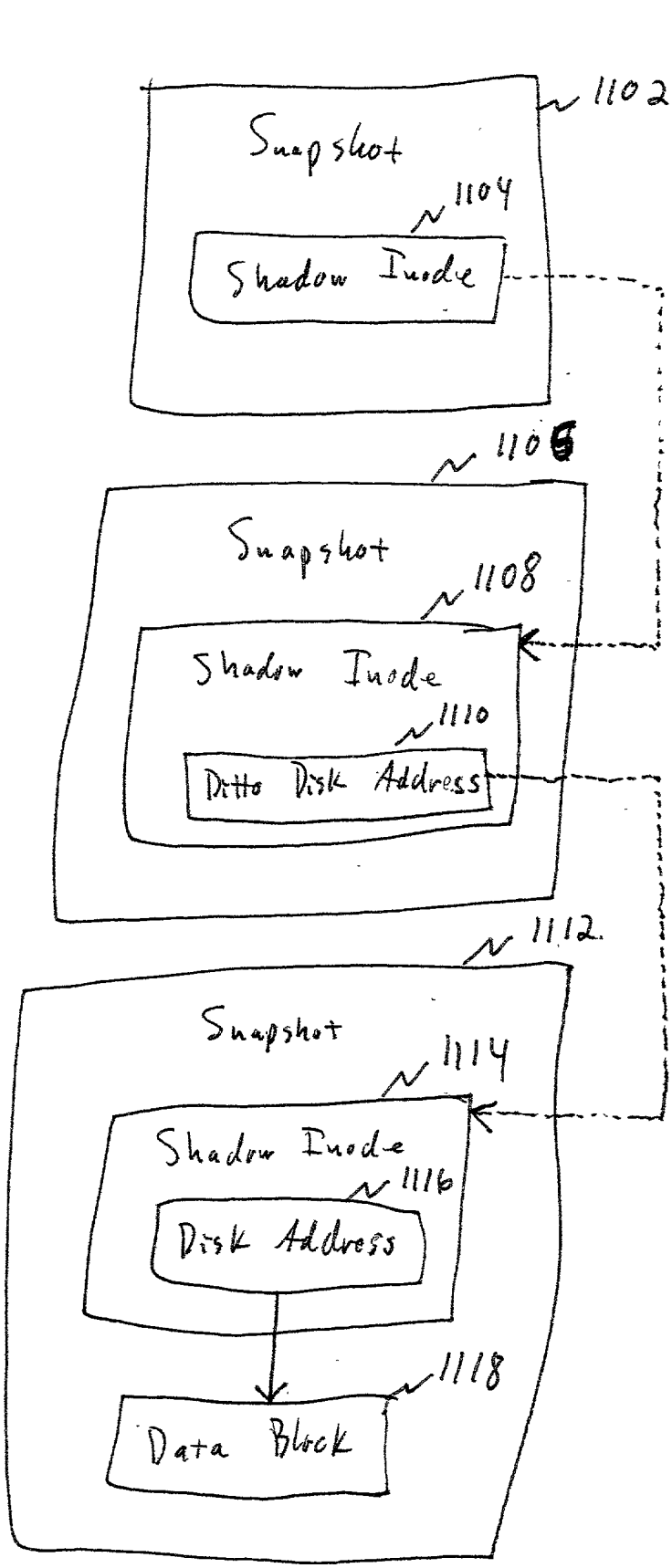

FIG. 11

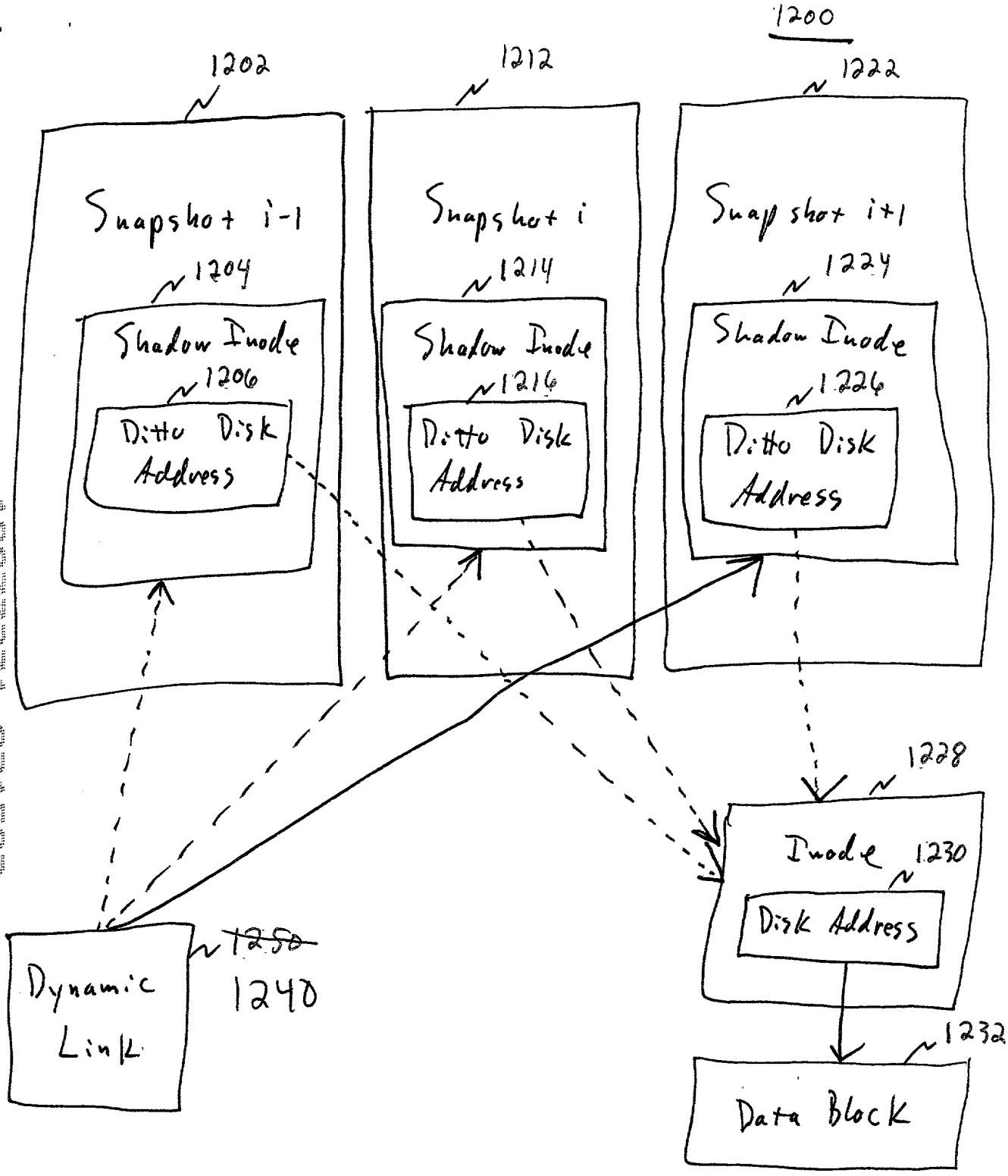
1200
1202
1212
1222
Snapshot i-1
1204
Shadow Inode
1206
Ditto Disk Address
Snapshot i
1214
Shadow Inode
1216
Ditto Disk Address
Snapshot i+1
1224
Shadow Inode
1226
Ditto Disk Address
1228
Inode
1230
Disk Address
1232
Data Block
Dynamic Link
1250
1240

FIG. 12A

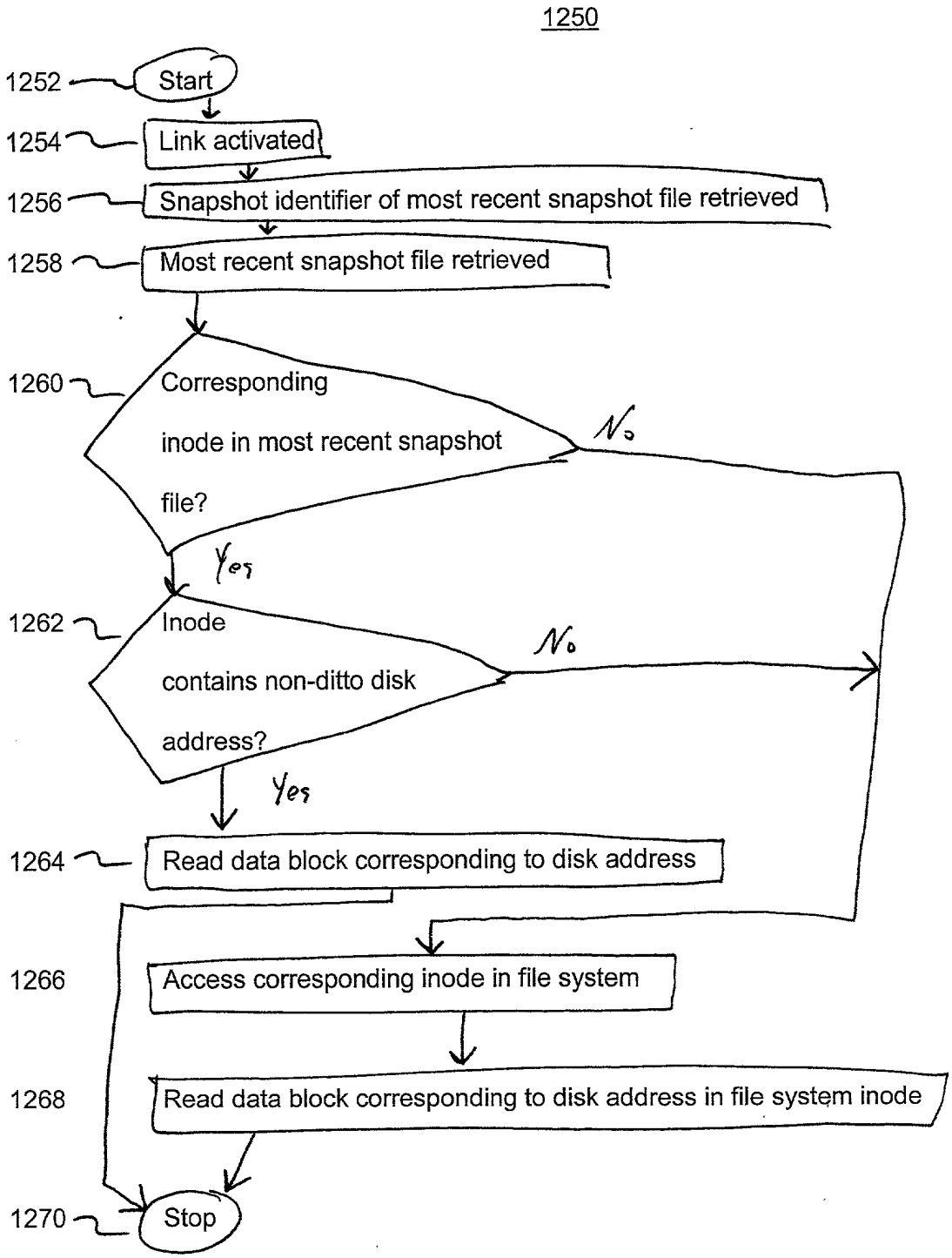
1250
1252
Start
1254
Link activated
1256
Snapshot identifier of most recent snapshot file retrieved
1258
Most recent snapshot file retrieved
1260
Corresponding inode in most recent snapshot file?
No
Yes
1262
Inode contains non-ditto disk address?
No
Yes
1264
Read data block corresponding to disk address
1266
Access corresponding inode in file system
1268
Read data block corresponding to disk address in file system inode
1270
Stop

FIG 12B

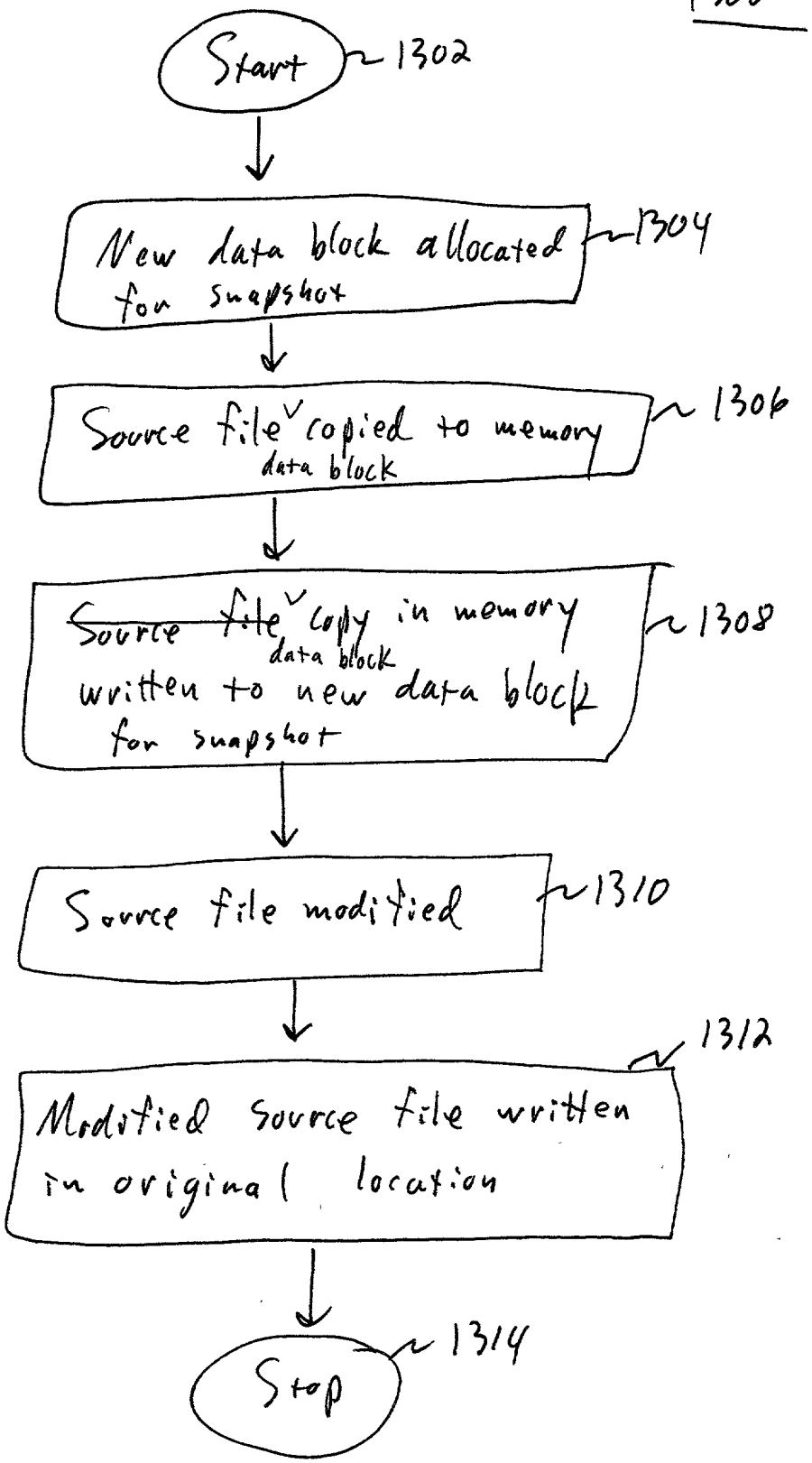
1300
Start
1302
New data block allocated for snapshot
1304
Source file copied to memory data block
1306
Source file copy in memory data block written to new data block for snapshot
1308
Source file modified
1310
Modified source file written in original location
1312
Stop
1314

FIG. 13A

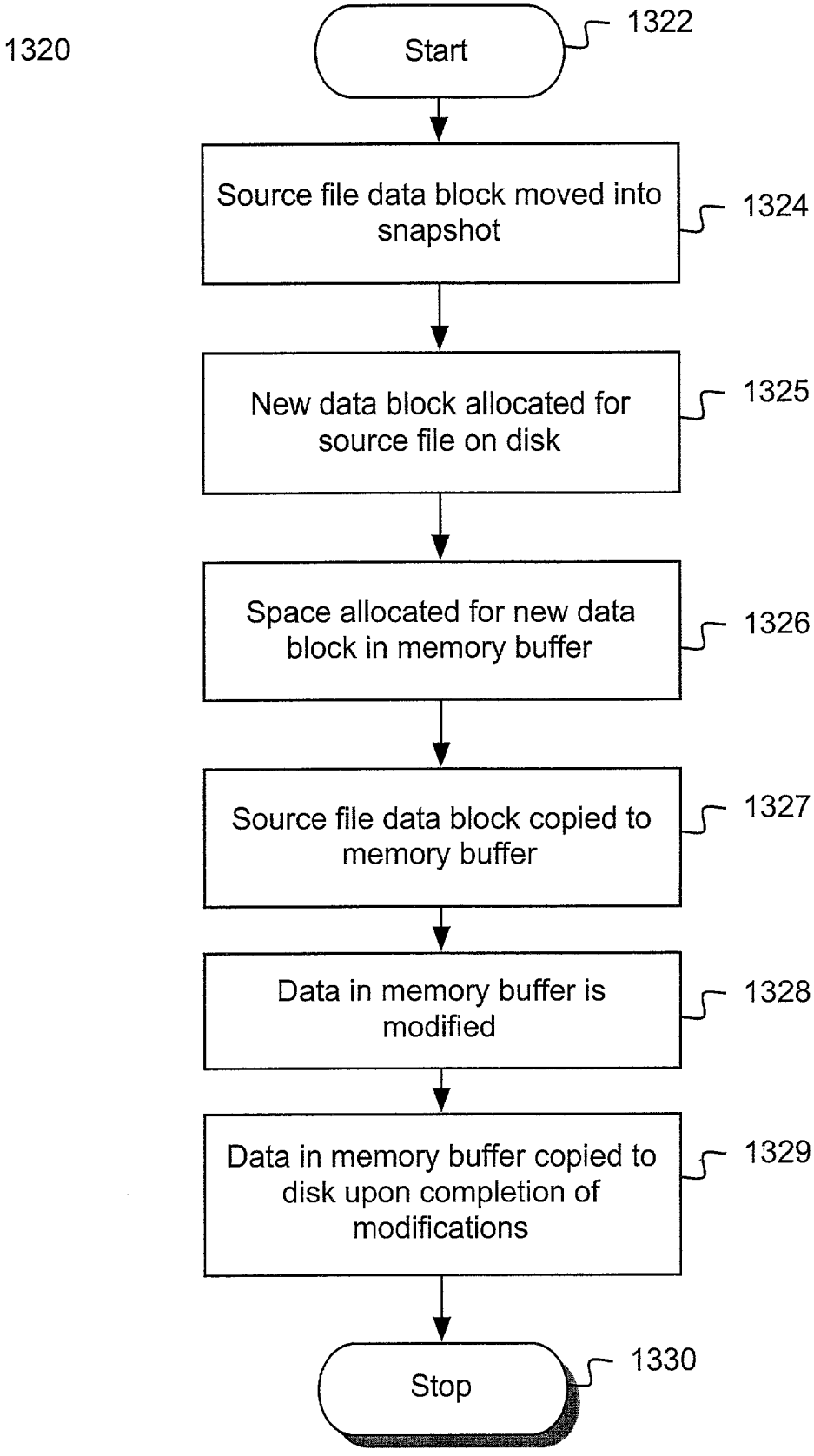
1320
Start
1322
Source file data block moved into snapshot
1324
New data block allocated for source file on disk
1325
Space allocated for new data block in memory buffer
1326
Source file data block copied to memory buffer
1327
Data in memory buffer is modified
1328
Data in memory buffer copied to disk upon completion of modifications
1329
Stop
1330

FIG 13B

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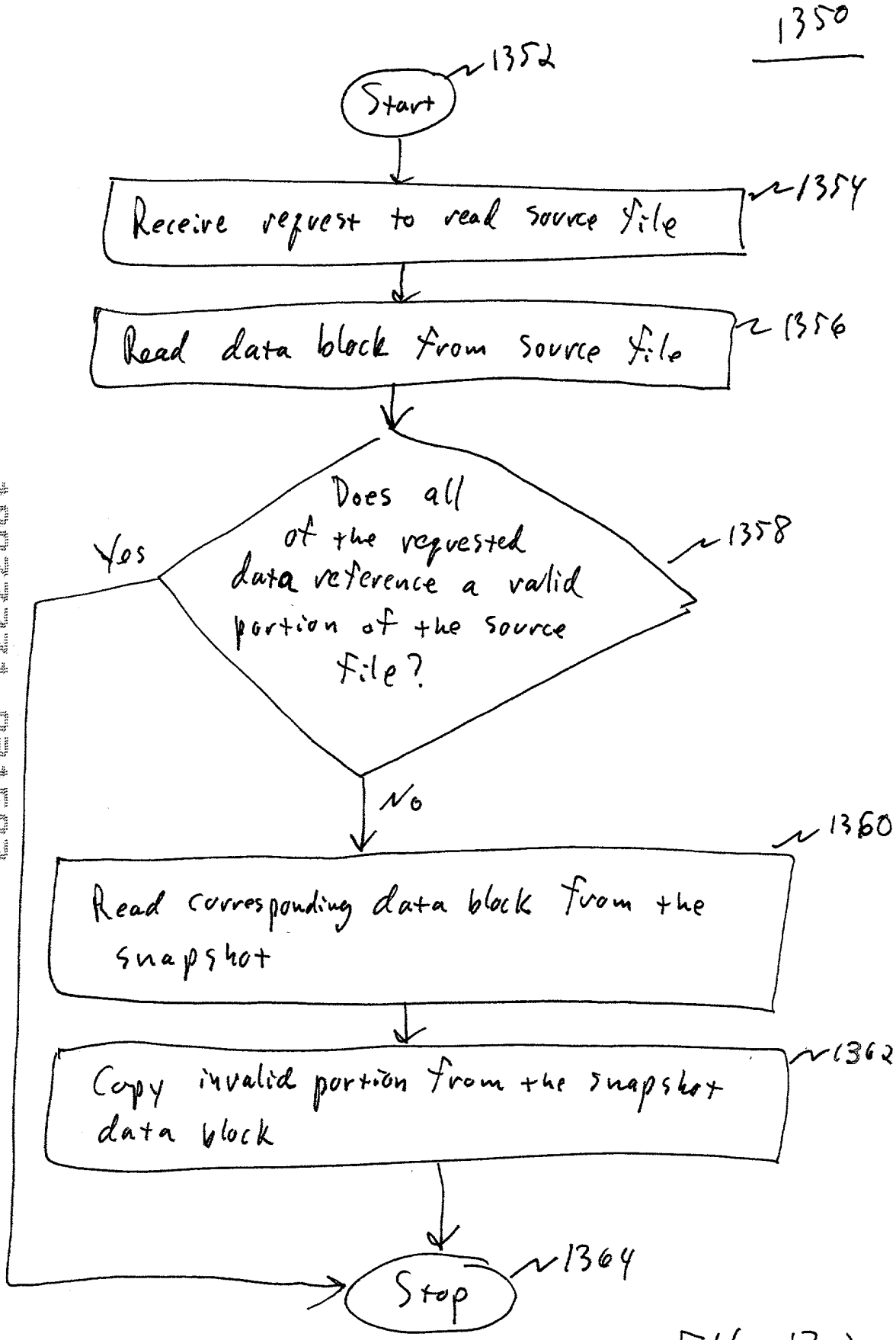

FIG. 13C

1400

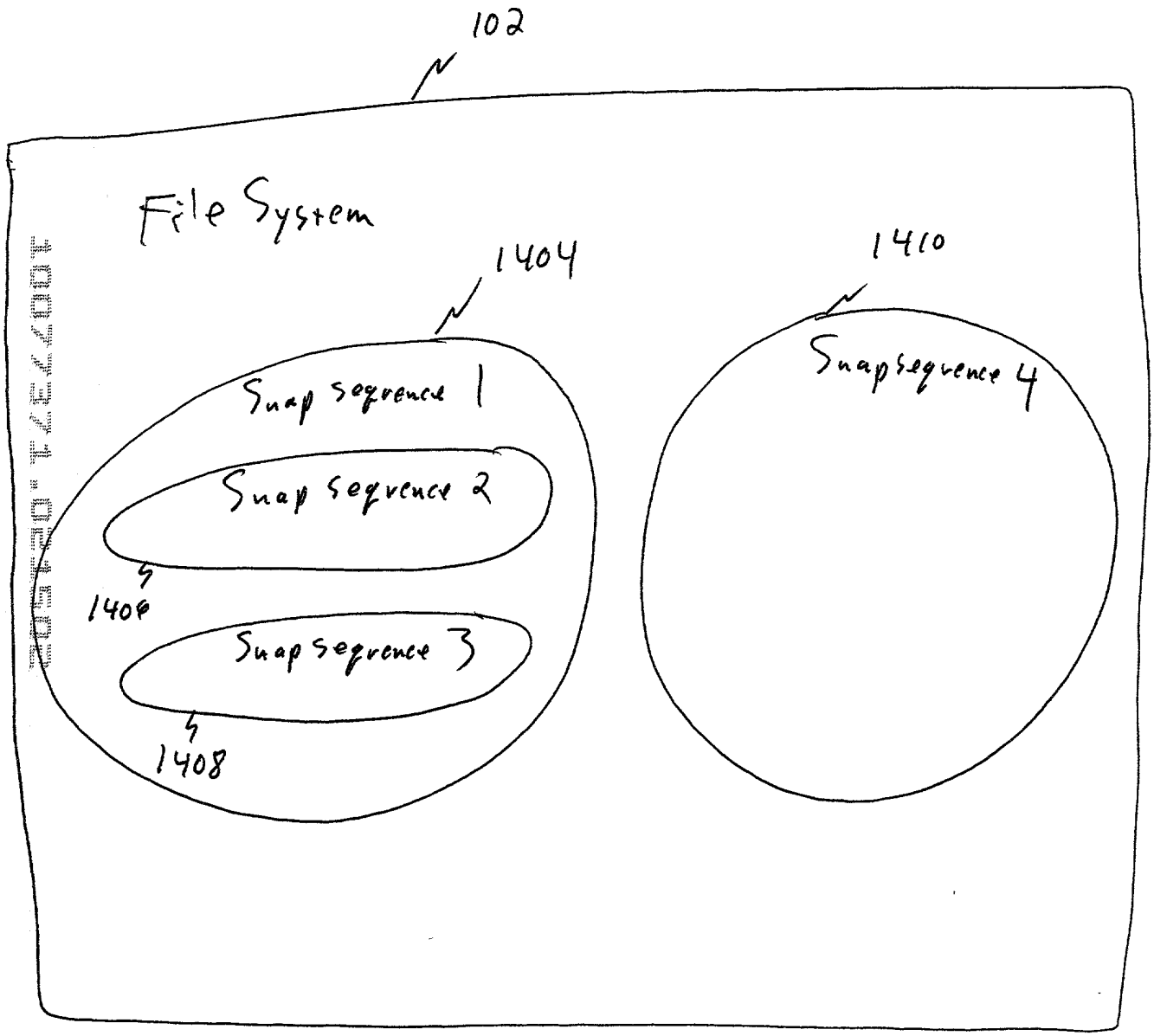
102
File System
1404
Snap segrence 1
Snap segrence 2
1406
Snap segrence 3
1408
1410
Snapsegrence 4

FIG. 14A

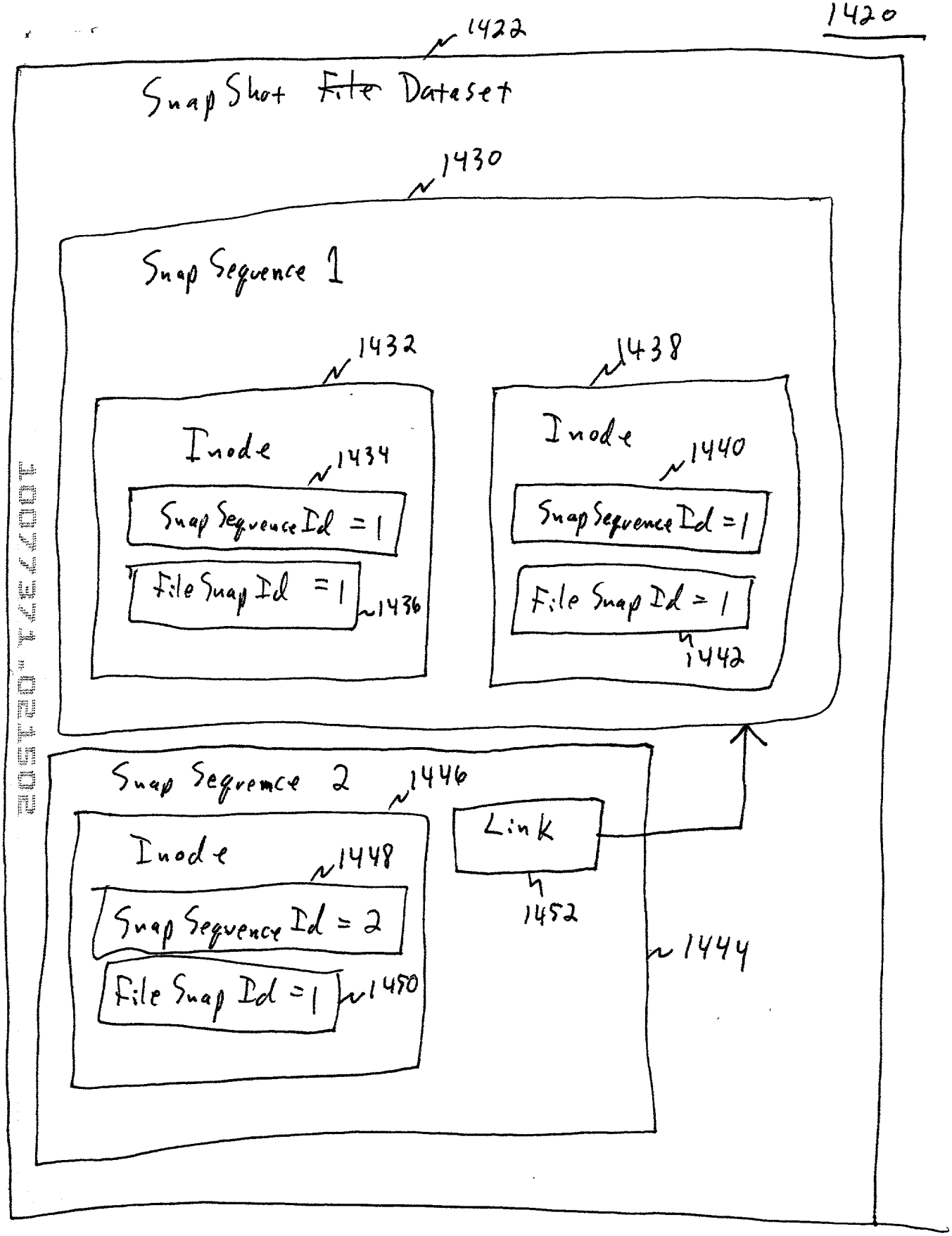
1420
1422
SnapShot File Dataset
1430
Snap Sequence 1
1432
Inode
1434
Snap Sequence Id = 1
File Snap Id = 1
1436
1438
Inode
1440
Snap Sequence Id = 1
File Snap Id = 1
1442
Snap Sequence 2
1446
Inode
1448
Snap Sequence Id = 2
File Snap Id = 1
1450
Link
1452
1444

FIG. 14B

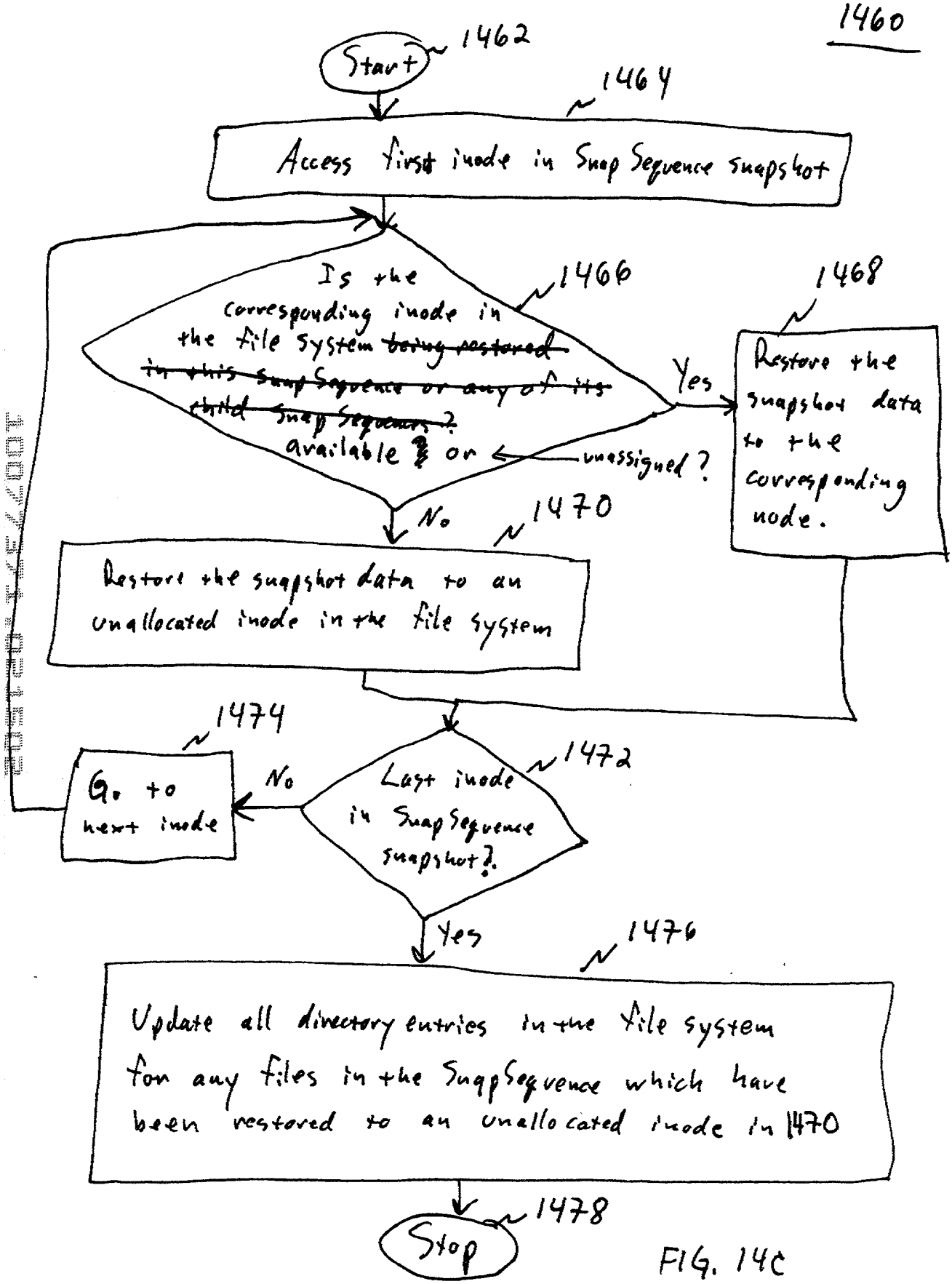
1460
Start
1462
Access first inode in Snap Sequence snapshot
1464
Is the corresponding inode in the file system ~~being restored in this Snap Sequence or any of its child Snap Sequences~~ available or unassigned?
1466
Yes
Restore the snapshot data to the corresponding node.
1468
No
Restore the snapshot data to an unallocated inode in the file system
1470
Last inode in Snap Sequence snapshot?
1472
No
Go to next inode
1474
Yes
Update all directory entries in the file system for any files in the Snap Sequence which have been restored to an unallocated inode in 1470
1476
Stop
1478

FIG. 14C

4005754.025500

1500

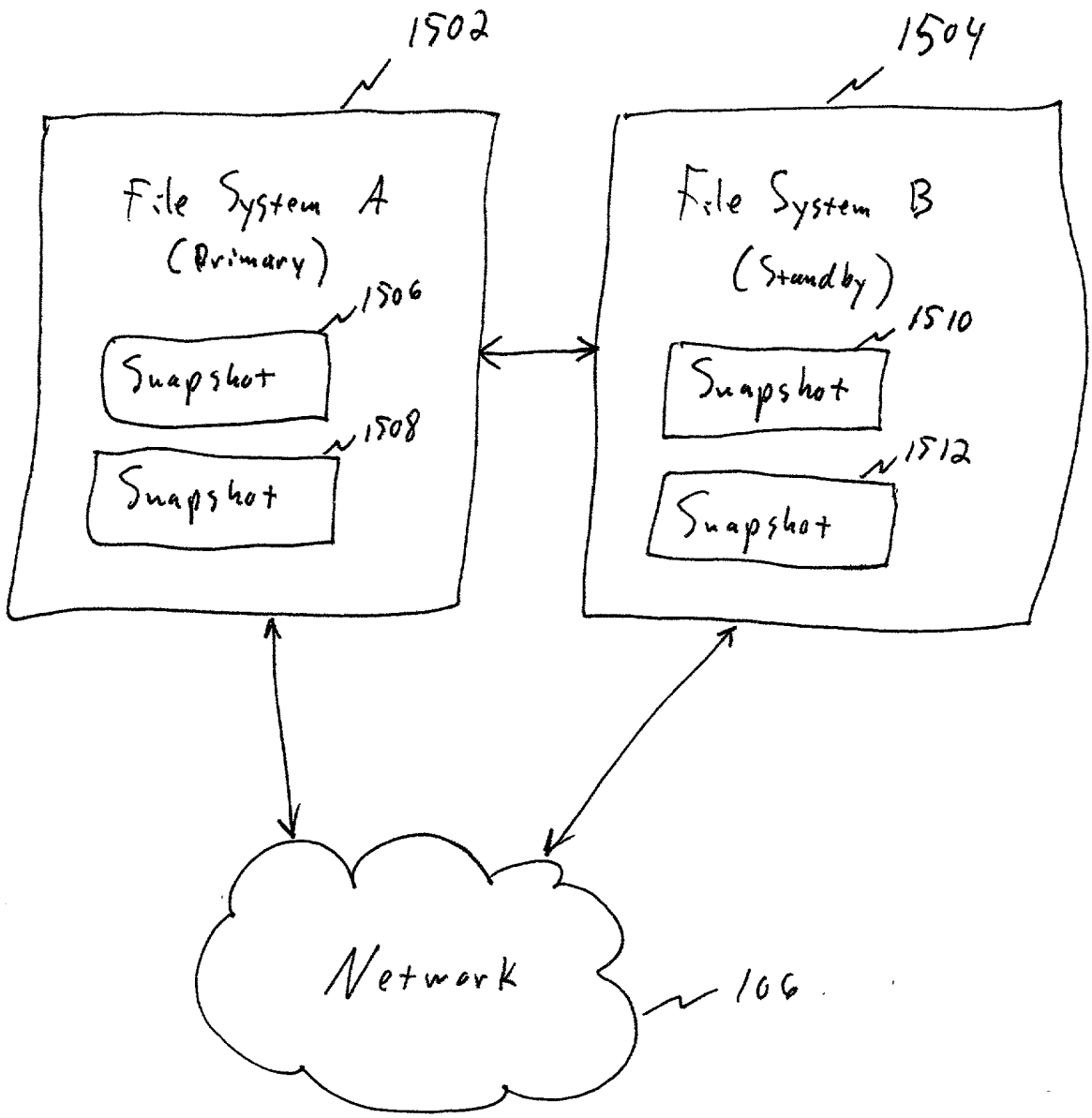

FIG. 15A

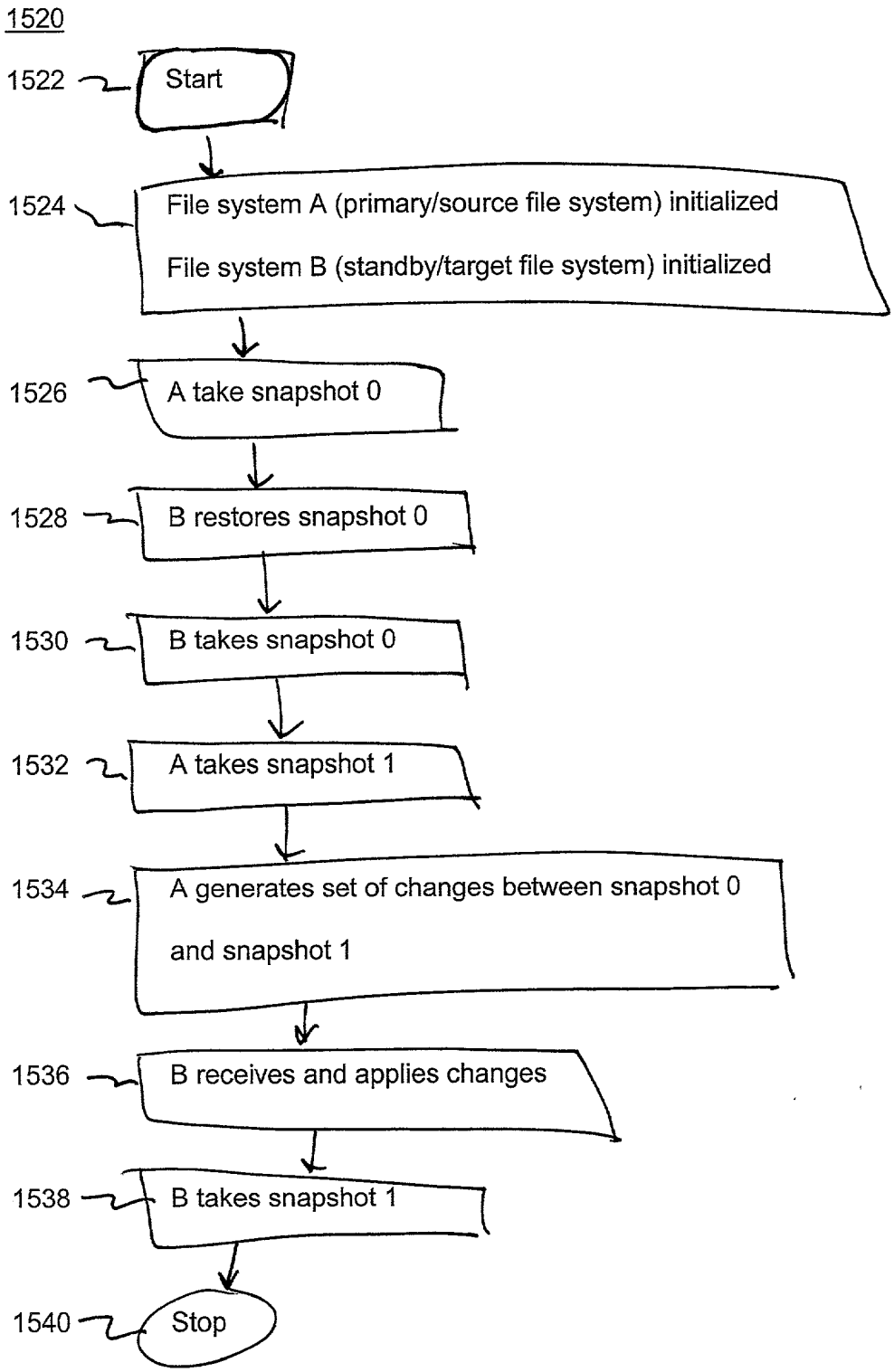
1520
1522
Start
1524
File system A (primary/source file system) initialized
File system B (standby/target file system) initialized
1526
A take snapshot 0
1528
B restores snapshot 0
1530
B takes snapshot 0
1532
A takes snapshot 1
1534
A generates set of changes between snapshot 0 and snapshot 1
1536
B receives and applies changes
1538
B takes snapshot 1
1540
Stop

FIG. 15B

1001.0571.0P1502

1540

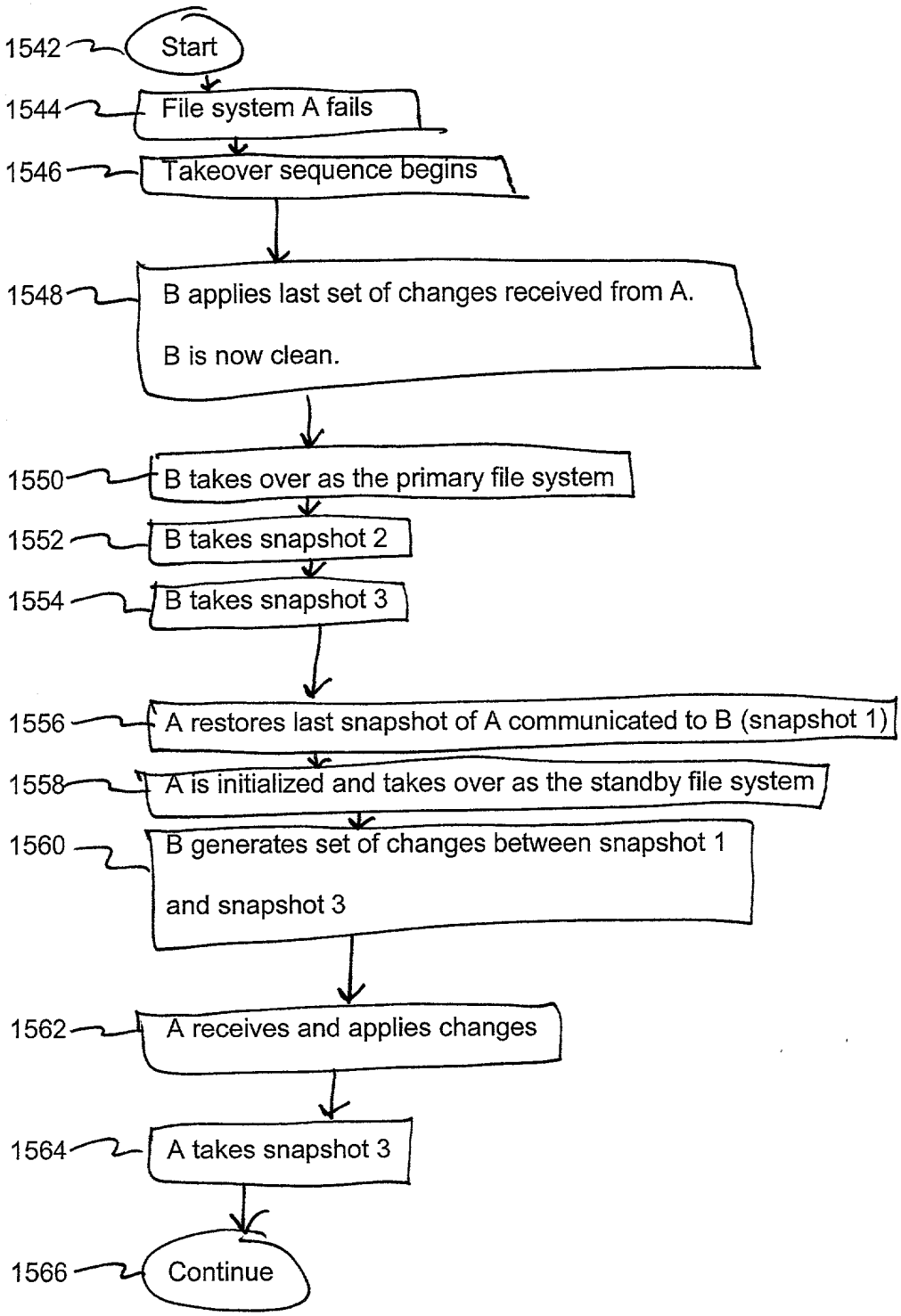

FIG. 15C

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1590

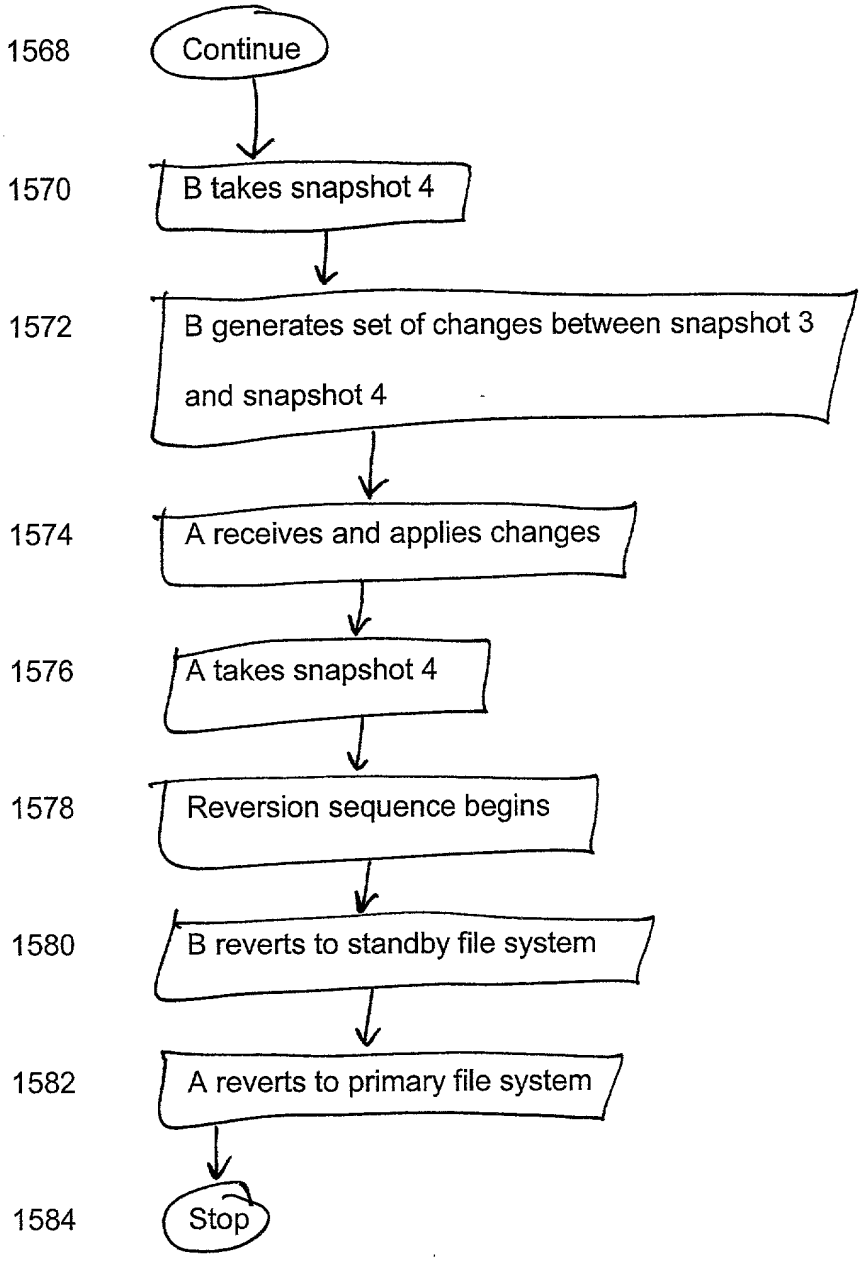
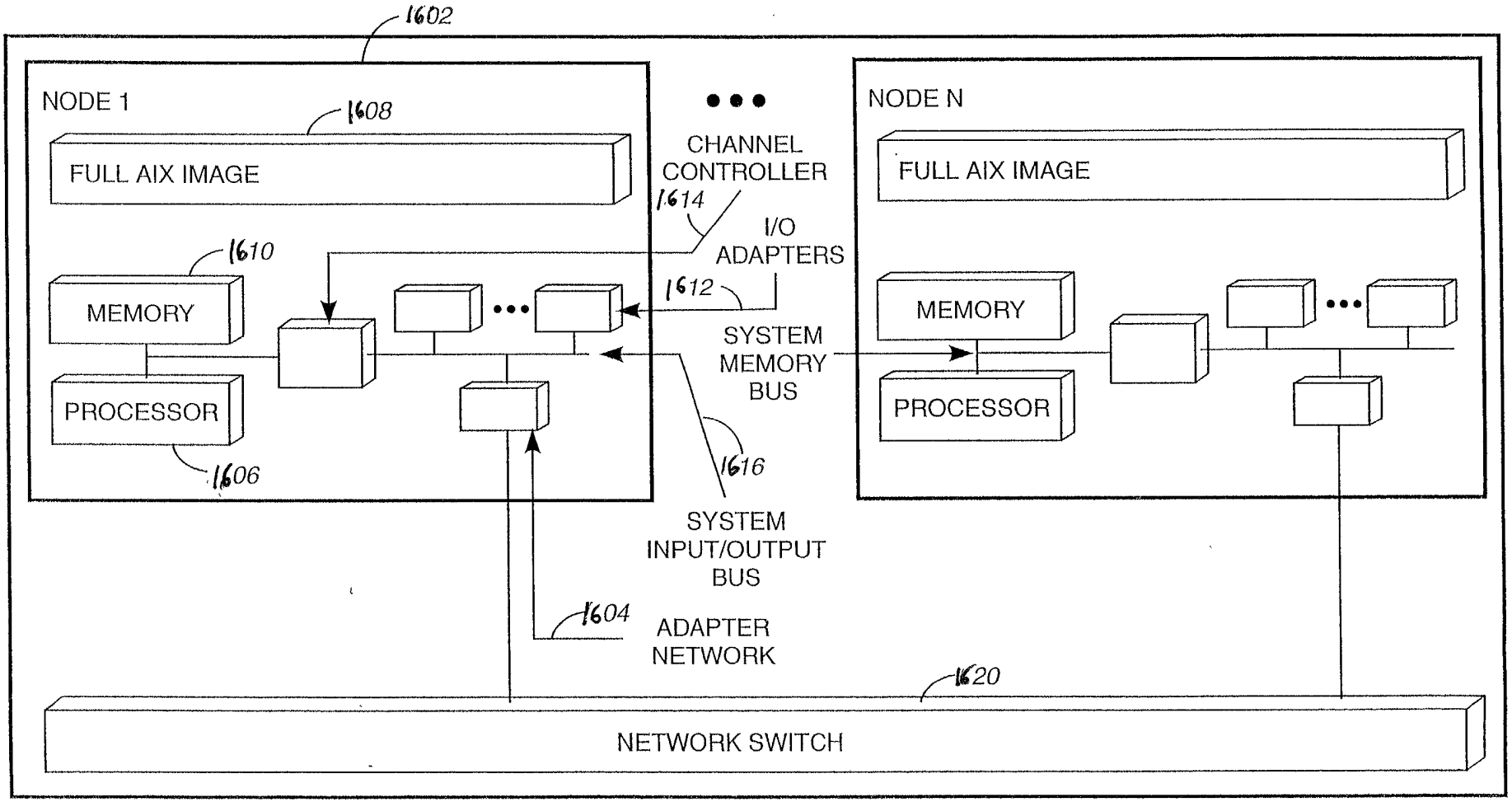


FIG. 15D

20ST20 "TZE/20DT



1600

FIG. 16

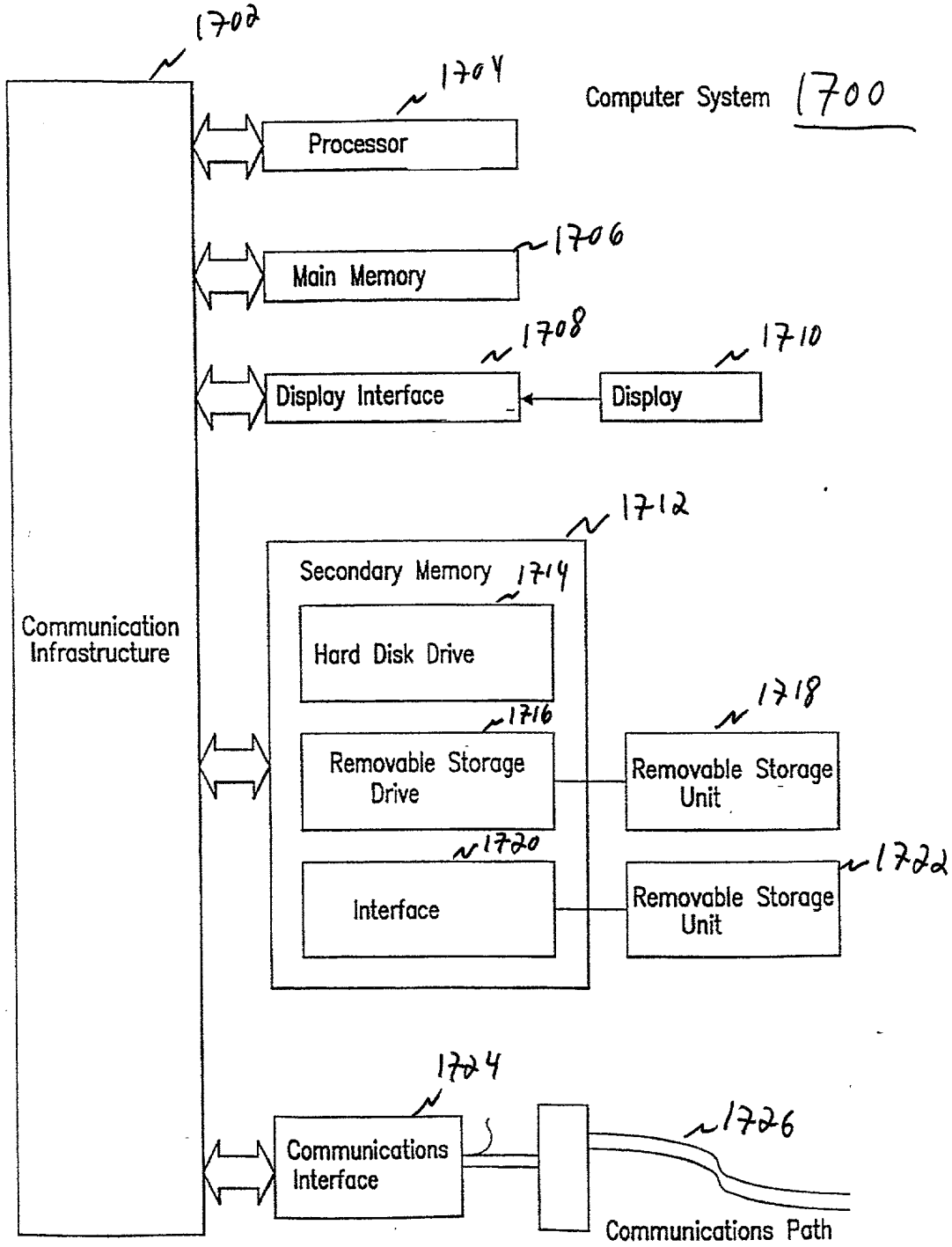

1702
Computer System 1700
1704
Processor
1706
Main Memory
1708
Display Interface
1710
Display
1712
Secondary Memory 1714
Hard Disk Drive
1716
Removable Storage Drive
1718
Removable Storage Unit
1720
Interface
1722
Removable Storage Unit
Communication Infrastructure
1724
Communications Interface
1726
Communications Path

FIG. 17